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The Brooklyn Bridge—Opened to Traffic May 24, 1883

An Engineer's View of
INVESTMENT BANKING REFORMS

By GREGORY M. DEXTER[1]

Engineers, auditors, and bankers are taken to task by the author of this article for practices that are not in the public interest; and a proposal is made, to be discussed in greater detail next month, that a bureau be established to make available to the public, at nominal expense, a rating for every security as it comes on the market.

BANKERS are about as unpopular today as, in 1929, they were popular. Numerous newspaper editorials and magazine articles blame them, generally speaking, for the great losses on supposed investments. One writer, in the *Nation's Business*, claims they unloaded "gold bricks" on the public. Another, in the *American Mercury*, defends them but admits reforms in banking procedure are necessary. The *Saturday Evening Post* has published articles by Frank A. Vanderlip and Will Payne that outlined possible reforms. Numerous legislative hearings have developed testimony showing that the abuse of public confidence has been too common. No wonder Prof. John Dewey said, some months ago, that we were in a "hell of our own making." Yet all this indignation and activity will be wasted unless the new laws, that are certainly coming, are supported by an aroused professional opinion which demands that bankers, auditors, and engineers serve the public better, by conformity to a higher code of ethics than in the past.

Criticism of almost anything is as easy as the proverbial locking of the barn door after the horse is stolen. So here also it will take no account of the excellent guardianship that bankers, auditors, and engineers have given to many investment issues. Anybody who has had fairly intimate contact with the analysis of proposed underwritings knows only too well how carefully they are studied in many organizations before they are offered for sale. Still, many serious mistakes have been made. Perhaps, therefore, an account of some of those which are fairly typical may serve a better purpose than praise.

WHO SHOULD PAY FOR THE INVESTIGATION?

During the world war a group of business men bought a manufacturing plant in order to assure themselves of certain materials it was producing. The plant proved to be a high-cost, marginal producer with much obsolete equipment. The purchasers subsequently proposed a first-mortgage bond issue in order to reimburse themselves for buying the company. They agreed to provide a banking house with the necessary engineering reports but the latter was willing to absorb the expense if the issue were underwritten.

Such an agreement, although rather common, is against public policy. The engineers are hired by the men who want the loan and not by the bankers. The engineers may have the highest integrity but they cannot fail to remember as they work who is going to pay their fees. It is much better for bankers to demand cash advances sufficient to pay for such advice as they may desire by engineers of their own selection. If the issue is underwritten, the advances may be deducted from the usual commissions.

In the case referred to, later developments proved the soundness of this recommendation. The engineers selected by the business men faced a difficult situation; while the manufacturing company was inferior, the men back of it had heavy financial interests in another industry. The first report was so mild that the reviewing engineer criticized it as misleading. He requested an unequivocal summary of their attitude. The assistant who had prepared the report admitted that, as originally written, it had contained such a summary but that his superior had forced him to take it out. The report, even as finally written, was dangerous for use by a banker or a business man who did not have the engineering training that would enable him to sense the fact that great advances in the industry had forced heavy obsolescence.

Following a conference attended by all those interested, the proposed underwriting was declined. It is significant, perhaps, that one of the principals in the engineering organization which prepared the report complimented the reviewing engineer on his broad grasp of the problem, expressed pleasure at the declination, and said that the report had really not been necessary. Very evidently they had strong objections to the proposed underwriting. They did not say so, however, in their report. They were using every diplomatic evasion at their command to avoid offending the business men who had hired them. Their paramount duty, however, was to the public, and in that duty they were remiss.

HALF-TRUTHS AND ADVERSE CRITICAL COMMENTS

Anybody who has had to review many reports of engineers and auditors knows only too well the feeling of hopelessness that comes from the conviction, when the review is completed, that the whole truth has not been told. Reports too often tell what is favorable

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and not what the banker wants to know. Here is a report on a gold mine, from a competent mining engineer, which unqualifiedly recommends the expenditure of half a million dollars but says nothing about the obvious uncertainties that are involved. There is the case of a report on a patented article which cost $12,000 and which was submitted to support a request for a loan of $750,000. A quick field check showed what the report did not mention, that numerous manufacturers had lost money trying to sell similar patented articles, that competition was keen among a number of well-established manufacturers for a limited market where the desirable product for any particular use had to meet widely varying specifications, and that tests by one large railroad had shown that this particular patented article was inferior to others, although railroad sales were the bigger portion of the total possible sales. Auditors' reports are easier to check since they usually carry limiting qualifications such as a statement that inventory has been taken at book figures (although obviously swollen) or that accounts receivable have not been confirmed (when letters to debtors would show that many of them are worthless). It is no wonder that many investment bankers have little more than preliminary use for many reports. Too many engineers and auditors seem to lack that quality of courage that forces into a report critical comments adverse to the supposedly best interests of their clients. Yet in the long run nobody finds any value in anything except the uncensored truth.

Many investors do not object to some speculative issues but they do object to buying supposedly conservatively placed bonds and stocks only to learn afterward that their assumed investment will have to be held for years before they will be able to get back what they paid for it. The general run of them do not believe that they can afford to pay for such guidance as is offered by investment services. They depend for advice, very often, upon salesmen who are under pressure to sell. They base their action, in considerable measure, upon the general reputation of the banking house behind the security without knowing how thoroughly the latter has been investigated. In all too many cases the investment banker has no auditor or engineer of his own. He frequently relies upon reports made to, and paid for by, his clients. He is certainly not using the disinterested advice of competent technical assistants, and to that extent his recommendations to the buying public have lessened value.

WHEN WARNINGS ARE IGNORED

Even when an engineer or auditor warns a banker of difficulties, the warning is too often ignored.

Some time ago an engineer for a group of investment bankers examined the proposed consolidation of a number of small public utilities. They had been inadequately financed, poorly maintained, and badly operated. He reported such factors, and added that several millions of dollars would be necessary to place the properties in reasonably good condition. He emphasized contaminated water supply, uncovered concrete storage basins in congested territories, water mains which signally failed to meet the standards of the National Board of Fire Underwriters as to fire protection, water supplies with bad tastes and odors, low pressure on household mains, the growing competition of municipally owned water companies, and other factors. The circular issued by the bankers and describing the securities did not mention these conditions nor did it give any indication that these properties were in such bad condition that some years of intensive work would be necessary in order to get them where they could meet the requirements of modern operating methods. The average investor never did learn that one of the investors' services gave the bonds a low investment rating after they were issued.

As another example, note that the American Institute of Consulting Engineers repeatedly warned bankers of the necessity for competent, disinterested, engineering advice in connection with Latin-American investments. The warnings were ignored with disastrous results.

A LIMITED NUMBER OF WORTHWHILE INVESTMENTS

Few have any idea of the limited number of worthwhile investments. In this respect the following story of conditions in the mining field is applicable to almost any investment. An officer of a well-known company told it some years ago. While the figures, now quoted from memory, are not correct, they are close enough to indicate the tendency. He said that out of 100 proposed mines brought to the attention of his company for purchase or investigation, 50 would be declared worthless after a brief office examination, another 30 would fall down under a preliminary field examination, and another 15 would be found worthless after a detailed geological study. This left five which went through further steps of study and even operation. Only one turned out to be a money maker.

Any engineer who has had experience in work for high-grade investment bankers knows that the proportion of dad to good in the grist of ideas he examines is not far from the experience of that mining company. Yet in spite of this known condition, so-called securities which can never have any future except failure are issued in great volume.

A few years ago a prominent investment banking house declined to underwrite an issue of stock for an industrial. The decision was based on a poor record of earnings, competitive forces which were developing better products, overproduction, and the very short life of most companies in the industry even when well financed. Yet within a few months a well-known brokerage house was selling the issue and had it listed on one of the exchanges. This house had capitalized the earnings of the company for the best six months in its history. The sale price of the stock, needless to say, soon dropped to almost nothing. The folly of such a procedure would be evident to any competent engineer or reputable banker who examined the company in the light of its earnings and history. Yet there is

nothing to prevent this practice. One good house turns down an issue only to see it sold by another which is not so careful of its clients' interests.

WHEN THE FEES ARE INADEQUATE

Engineers and auditors are too prone to accept engagements for fees which are so low that a thorough investigation is not possible. Bankers are equally to blame for this practice.

Some time ago a banking house proposed a bond and stock issue of about $2,000,000 as a construction and permanent loan. An engineering organization was hired to prepare a report as to its safety. The fee paid was $2500. Engineers know that perhaps $500 of such a fee should be set aside for profit and that about $1000 is required for overhead. This leaves about $1000 to pay the salary and traveling expenses of an engineer and necessary assistants. Not very much that is worth while can be done for such a sum.

The report in this instance was favorable; but the property had scarcely been placed in operation before it became apparent that it could not earn its first-mortgage interest. An investigation at that late date showed that plenty of data were available to a thorough investigator, and that a consideration of these data would have prevented the making of the loan. No engineering investigation worthy of the name could have been made for less than $5000. The size of the loan justified such a charge as a minimum. In this case the engineers were more to blame than the bankers for the loss which investors suffered. While the bankers drove too hard a bargain, the engineers were so anxious for work that they grabbed at what they could get.

Adequate fees must be charged if good, thorough engineering work is to be done. The use of relatively poorly paid assistants should be discouraged. More senior engineers of superior education and experience could be used if fees were more often as high as they should be. Bankers, engineers, and most important of all, the public would be distinctly benefited by the increased use of such men. It is astonishing that a banking house and an engineering corporation would be willing to stake their future reputation as to the safety of an investment of about $2,000,000 on a report which cost $2500.

WHEN THE ENGINEERING REPORT IS DISREGARDED

In another case an issue of several millions of dollars of bonds and stocks for the consolidation of some public utilities came up for review. Well-known engineering organizations had made the necessary appraisals. Examination showed that these were based on reproduction costs and were heavily loaded with allowances for franchise and going-concern values and the like. It is doubtful if any public-utility commission in the United States would have passed them as reasonable. It is certain that in the state where the properties were located the commission would not allow much more than original cost plus a small allowance for overhead charges. No way had ever been found of successfully appealing to the United States Supreme Court from the decisions of that commission.

The reviewing engineer had the temerity to suggest to the president of the public utility that the use of such appraisals in advertisements to the public was questionable. He was laughed at for his pains.

The banking house inserted in its circulars and advertisements the usual clause which relieved it of any responsibility. While such a clause is probably necessary in order to prevent lawsuits which may arise over honest mistakes in judgment, it is objectionable in that it permits the banking house, auditors, and engineers to slide over various statements as unimportant which would never be allowed if there were any chance of a review of them in court.

Here again the banking house has only partial responsibility. The merest tyro in engineering should have known that such appraisals would be very misleading to investors who might compare the size of the bond issue with them. For the engineering organizations to claim that they were honest expressions of belief as to what was fair is begging the question. The public utility would not, as a practical matter of good public relations with the commission, attempt to get rates based on such extravagant appraisals. We are justified in questioning the ethics that permits an engineering organization to turn them in without a qualifying clause that would prevent their misleading use by bankers.

THOROUGH INVESTIGATIONS ARE NECESSARY

One engineer has an outline of some 1200 questions which he uses in making an investigation of an industrial company. These are suggestive and are used as a basis for more questions which naturally develop as facts are laid before him. They cover almost everything connected with the company's business from finances to sales, from purchasing and manufacturing to shipping. But the analysis of the answers is not completed in a few days. If more investment bankers insisted on the thoroughness that such questions imply, there would be fewer security issues and a good many more successful corporations. The troubles that companies get into are so ridiculous that if taken in time they can usually be cured. But bankers and corporation executives are like most humans; they are not overfond of the facts which are developed by cold-blooded analysis. Engineers and auditors, consequently, are not used so often or so long as they should be. The public goes merrily on buying securities which should not have been sold until the company on which they were issued had been reorganized.

DEPRECIATION A DIFFICULT PROBLEM

Probably the most troublesome question which bankers face is that involving depreciation. Everybody who has ever had anything to do with it has an opinion as to what is reasonable. Much of the opinion encountered is mere guesswork. Only a detailed analysis of the conditions in the industry, such as new machinery with

the higher operating rates thereby made possible, new processes and methods, and the physical condition of existing machinery, will permit an intelligent answer. The necessary data are frequently found in an analysis of sales conditions and competition. It is not enough for the investment banker to consider observed depreciation. He must anticipate, if he can, what changes obsolescence will force in a few years. The troubles of the prophets are so well known that further comment is not necessary.

Yet engineers and auditors are not giving bankers the help they should get in these matters. In one important dispute there was a difference in asset value, as determined by two firms of auditors, of about $46,000,000 which was largely due to a difference of opinion on depreciation. In another case a public-service commission recently reported a valuation of about 40 per cent of that claimed by the engineers for the public utility and described the latter's figure as "extravagant," "absurd," and "ludicrous." Engineers have been guilty of equally glaring differences on appraisals for bankers. The merits of these controversies are not important. It is important to note that the public wants fair valuations. If engineers and auditors cannot agree, how can we expect the banker to know what is reasonable?

DIFFERENCES IN ETHICAL STANDARDS

Most of the trouble comes from a clash in ethical standards. Too many business men and corporation executives give scant heed to exaggerated representations if they will help a sale, out-jockey a competitor, or get a loan. They deal with lawyers whose code of ethics permits them to make partizan pleas in their clients' interests. They frequently fail to realize that the code of ethics of engineers and auditors requires them to report conditions exactly as they are and regardless of whose interests may be advanced or hindered. There are, unfortunately, engineers and auditors who do not adhere to this rigid code of ethics with results that are frequently disastrous to the investor.

AN INVESTORS' SERVICE RECOMMENDED

An engineer delights in the satisfaction that comes from looking at the product of his brain and hand, such as a beautiful and durable bridge, a smoothly running piece of machinery, or an economically operated factory. There are certainly many auditors and bankers who take a similar pride in the careful analysis and successful sale of good securities. To such auditors, engineers, and bankers the losses which the general public has suffered through the purchase of practically worthless securities are distressing because they are so unnecessary. A partial solution of this vexing problem of adequate protection for the public in its investments would be the setting up by investment bankers of a bureau which would make available to the public, at nominal expense, a rating for every security as it comes into the market. The concluding portion of this article, which will appear in a subsequent issue of MECHANICAL ENGINEERING, will discuss this proposal at greater length.

Gerald Young

HOW DO YOU THINK?

By GEORGE M. EATON[1]

RECENTLY an eminent educator[2] criticized American engineering training because of the absence of a definite plan to inculcate in the minds of the students the habit of independent thought. He defined our training as a memory-stuffing process, stating that our curricula are so loaded with fact data that the student has no time to think, let alone time to learn how to think.

To the layman, the task of teaching independent thinking appears very difficult. If the teacher is an independent thinker and is able to impress his own habit of thought on his students, they may profit greatly, but there is some question about their independence. They may, however, from this start eventually evolve a state of independence.

In an effort to reach this goal, which has extended over a good many years and which is still in progress, the author has worked out a rather definite procedure for his own guidance. Not long ago this was outlined to a friend with the result that a request was made for this article.

No rules for thought will be equally constructive for all types of mind. Therefore, the system here presented is not prescribed as a cure-all. It has, however, proved helpful to some engineers.

The system is a method of written analysis in which an orderly procedure is assured by following the steps provided in the form shown in Table 1. It was developed specifically for use in the development of new machines, but it has proved to be applicable, in general principle, to any situation where it is necessary to gather and analyze fact data and reach a decision leading to action.

In behalf of the cause of independence, it is urged that any one who chances to decide to adopt a definite thinking machine avoid the use of this particular machine as it stands. He should build his own machine.

The master form, such as that shown in Table 1, is in a state of continual flux, and is modified almost every time that it is reviewed critically. Otherwise, thinking ceases to be independent.

Item 1 of Table 1 is hard to obey but it is of fundamental importance. At the start of the attack on a new problem the mind must be focussed solely on the completeness and accuracy of the specification.

TABLE 1 WRITTEN ANALYSIS OF A SPECIFIC PROBLEM

1	Close the mind resolutely to all thought of solution till 2 and 3 are completed			
2 Define problem	Ideals; must be satisfied	No compromise	Consult with those acquainted with problem, but reserve right to doubt	
	Desirables	Can compromise		
	Undesirables	Can compromise		
	Intolerables	No compromise		
3 Assuming problem solved	Is demand now urgent?	Is attack on problem justified?		
	Can market be developed?	Decision	Go ahead; state reason	
	Effect on employment		Quit; state reason	
	Economic and social effect			
	Steps for social protection			
4 Lines of attack	Past experience	Of self	Acquaintances	Avoid till all other avenues have been followed to bitter end
		Of others	Literature	
	Applied Science	List possibilities		
	Pure Science	List possibilities		
	New Research	List possibilities		
5 Tentative solutions	Written description and sketch of every scheme			
	Include every scheme, regardless of practicability			
6 Eliminative analysis	Vertical list of schemes			
	Horizontal list of determining items			
	Evaluate each scheme under each determining item			
	Indicate absolutely condemning features, discarding schemes affected			
	Indicate bad but less serious features, discarding in order of undesirability			
	Select least undesirable scheme (*Never try to select best scheme*)			
	Weigh selected scheme against item 2			
	Try to prove selected scheme inadequate			
7 Decision	Go ahead			
	Search for better solution			

Item 2 brings out a clearer definition of the problem than any of the other classifications with which the author experimented. The positive and negative features are often only differently worded repetitions of each other. But it has been found that the use of both the positive and negative points of view sometimes brings to light an important consideration which otherwise might be overlooked. These four categories of factors form the complete foundation for the subsequent

[1] Director of Research, Spang-Chalfont & Co., Inc., Ambridge, Pa. Mem. A.S.M.E.

[2] "Educational Preparation for Creative Technical Engineering Leadership," by R. E. Doherty. Mechanical Engineering, vol. 55, no. 2, February, 1933, pp. 90–94.

analysis, and they must be impregnable. In important situations it is wise to return to them repeatedly in a savage attempt to break them down.

Item 3 is advisable because it is always possible that a clear understanding of the problem should carry with it the recognition that the original belief in the justification of the attack was incorrect. At the time of the recent addition of the sub-items on employment and social effect, the benefit of their inclusion looked doubtful. But the very fact of having them continually in evidence has born fruit in a small way which is being covered separately.

Item 4 is in direct contradiction to the procedure followed by many. There are definite advantages that may be cited in favor of a thorough review of everything that others have done before launching one's own attack. But it has been the author's experience that there is too much danger of following the lead of others and missing some vital possibility when one's attack is other than entirely independent. The review of the literature should be made after the completion of one's own analysis.

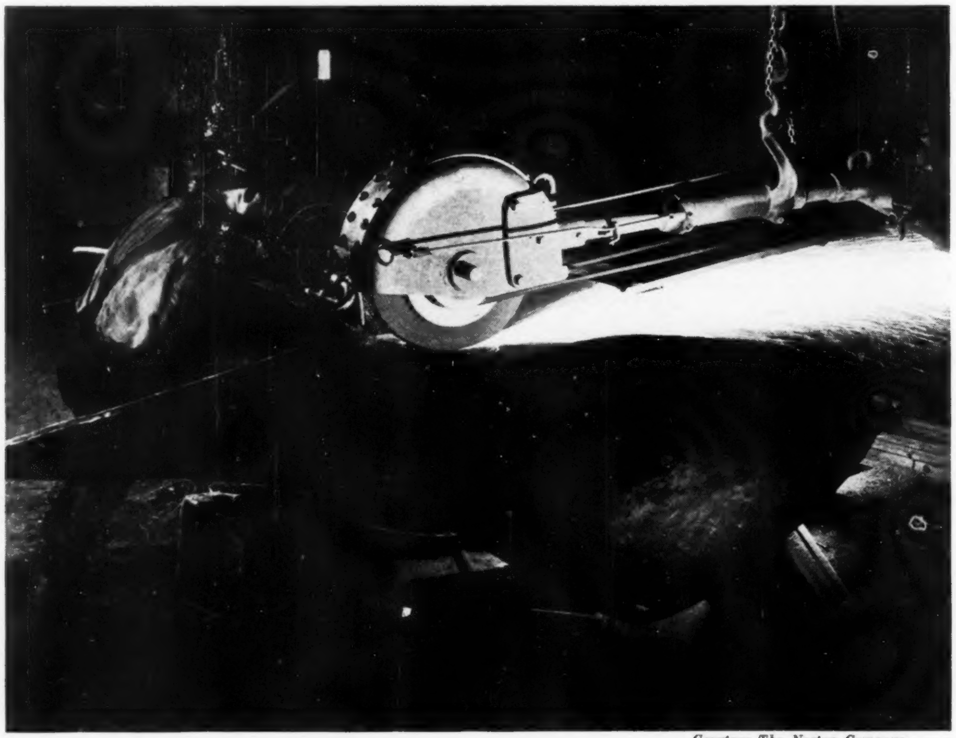
Item 5 covers the phase of detailed scheming. Sometimes a scheme that appears to be very foolish when considered in toto has one novel feature that can be incorporated in a practical development.

Item 6 is perhaps the key-note of the whole system. It is difficult for the inventive mind to wrench itself away from the bubbling enthusiasm generated by the birth of a new idea. Almost inevitably some pet scheme stands out among the candidates for selection. The beauties of this scheme overshadow its deficiencies in the "fond parent" mind of the inventor. For this reason it has been found absolutely necessary to proceed on the negative side, throwing out the worst schemes successively. If the eliminative analysis is laid out with the set purpose of proving the superiority of some pet scheme, then the analysis is a waste of time. Absolute honesty is a prime essential, and unless one can go through the work coldly, letting the chips fall where they will, he is not capable of conducting any real analysis.

In filling out each space in the tabulation, the mind must be closed to everything in the world except the truth and fairness of each specific evalution by itself. When this course is followed through with patient honesty, the selection of the least undesirable scheme is assured if sufficient essential facts are known. The written tabulation then forms a permanent record of the course which it has been decided to follow, and of the reasons for that decision.

It is not germane to go further into the details of this system. Each step is divided into major classifications which are then broken down to the closest possible approximation of fundamental details, the general form of scheduling being similar to the master form.

Some men are so fortunate that they can go through the operations of analysis mentally without the burden of writing, but there are a great many more who only think that they can do this. We admire and envy the gifted individuals whose minds cut through quickly and reliably to the logical solution. But we find it essential to reduce analyses of important issues to writing, and in an orderly manner.



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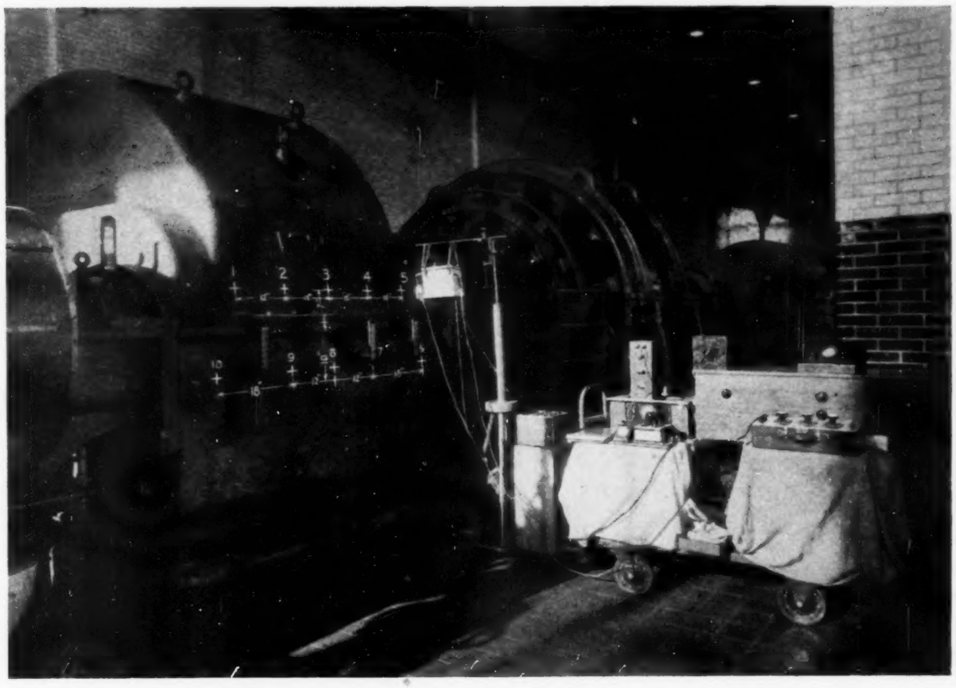

FIG. 1 SOUND MEASUREMENTS ON AN ACTUAL INSTALLATION

[In this case, wave patterns were sufficiently averaged by averaging the readings taken at the 10 stations indicated in chalk on the side of the gear unit. (See "Noise Specifications for Large Reduction Gears," by E. J. Abbott, *Jl. Acoustic Soc.*, April, 1932, p. 445.)]

Why Use SOUNDMETERS?

Advantages and Limitations of These Instruments

By E. J. ABBOTT[1]

WITH the rapid growth of noise consciousness, and the demand for quieter machinery of all kinds, many have come to feel the need for numerical measurements of sound.

TYPICAL ATTEMPT AT SOUND MEASUREMENT

The typical procedure seems to have been somewhat as follows: Surveys of available sound-measuring equipment showed it to be expensive and often not well suited to the problem at hand, and accordingly it was decided to build a homemade outfit. Some one with a bit of radio experience was uncovered in the organization, and he proceeded to assemble a microphone, an amplifier, and an indicator meter. This was duly demonstrated, and it was clearly shown that a reading was obtained when the noise was on, and a much smaller one when it was off. Of course there remained a few details to be worked out. As every one says, "We do not want to go into the fine points of analysis and all of that. All we need is something to tell us which sounds are louder and which quieter." But there comes the rub.

When such outfits were used, the experimenter found that on the average they agreed fairly well with the observers' ears, but there was a disturbing fraction of perhaps 25 per cent or so which was divided between samples which the instrument would reject and the ear would pass, and those which the instrument would pass and the ear reject. Another check often tried was that of selecting a group of machines covering a considerable range of loudness, and attempting to arrange them in order from the loudest to the quietest on the basis of meter measurements. It was usually found that every change of microphone location, speed, or similar condition resulted in an altogether different order of grouping. These changes were by no means small; usually measurements were obtained which showed a smaller reading for the noisiest machine of the group than was obtained on the quietest machine under identical conditions.

These discrepancies were correctly attributed largely to peculiarities in the microphone (which was selected for cheapness instead of quality and constancy) and to point-to-point variations in the sound; and the happy idea was reached that both of these could be eliminated by the use of "vibration pick-up." Preliminary tests with this were very encouraging on account of the freedom from extraneous sounds and the greater energy available, which latter allowed the removal of a couple of stages of amplification. Additional work, however, proved that the data were but slightly if any more consistent than before, and the experimenter was forced to the inevitable conclusion that the beautiful dial readings bore little or no relation to the things which he desired to measure. This little drama has been repeated scores of times in various plants throughout the country during the past few years, and most of the instruments are now gathering dust in some corner or decorating a scrap pile.

A few experimenters took a new grasp on their appropriation of time and funds and either purchased complete meters or the

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necessary parts with which to construct real soundmeters. Such meters have known frequency-response characteristics which can be properly adjusted to be suitable for the work at hand, constancy of calibration, and range to cover the sounds to be measured. In general the best equipment that can be obtained is none too good, and its cost runs into thousands of dollars.

FUNDAMENTAL OBSTACLES TO SOUND MEASUREMENT

Unless suitable sound-measuring equipment is available, readings are of little or no practical value, but even when good equipment is used so that the sound pressures at the microphone can be accurately measured, there remain two fundamental difficulties in the practical application of sound measurement. One of these lies in the nature of sound itself, and the other in the way the human ear "adds up sounds."

Wave Patterns. The manner in which machinery radiates sound is very complicated. The sound may originate in the vibration of one or two small parts, but ordinarily a slight amount of the sound heard at a near-by point is radiated from these parts. Instead, audio-frequency vibrations are transmitted to the rest of the machine, many parts of which are usually much better radiators of sound. Each of the scores of vibrating surfaces on the machine sends out its own train of sound waves of certain phase and amplitude, and these trains of waves cross and recross, reinforcing each other at certain places and tending to neutralize in others in the most complicated fashion. The points of maximum and minimum sound are very irregularly spaced, and the amplitudes of the different maxima and minima vary greatly. As a result the loudness and quality of the sound vary greatly from point to point near the machine. This condition is usually aggravated by sound reflected from surrounding objects, but even if the reflected waves could be entirely eliminated, the difficulty would still exist on account of the multiplicity of radiating surfaces on practical machines.

As a result of these complicated wave patterns, the loudness of the sound from a machine does not diminish steadily as one moves away from the machine. With speed and other conditions constant, the loudness at any one point remains constant with time; but there are large variations in loudness from point to point in space. These variations are not evenly spaced, nor of the same size, although they are more closely spaced for higher-pitched notes. The general level of the sound averaged over a region of, say, 1 cubic yard of space gradually diminishes as the distance from the machine is increased, but one is almost certain to encounter points some feet away from the machine where the loudness is considerably greater than at points within a few inches of the machine. Ordinarily, notes of single frequency show these point-to-point variations in space of the order of about 20 db (a factor of 100 to 1 in sound energy), and the so-called "total noise" usually shows variations of the order of about 10 db (a factor of 10 to 1 in sound energy).[2] Larger variations are often encountered.

As will be shown presently, these variations are very much larger than the usual differences between machines which it is desired to measure. A slight change in speed or other condition is ordinarily sufficient to shift the wave pattern entirely, even though the average value is not affected, and different samples of the same type of machines are quite sure to be sufficiently different to show different wave patterns. As a result, measurements taken at any single point near a machine are usually of little practical value in obtaining a noise rating for that machine, even relatively to other machines of the same type.

To obtain average noise ratings it is obviously necessary to average these effects. On account of the uncertainty of this averaging, and the fluctuations which appear to be inherent in most machinery noise, it is usually difficult to measure the noise of a machine closer than a decibel or two. While this uncertainty does not represent a very noticeable change, it will be shown presently that it may be very important in some cases.

In certain cases of routine noise inspection considerable success has been obtained with meters which do not average the standing waves, but which give comparative measurements at a corresponding point in the pattern. It is believed that there is a considerable field for this type of special-purpose meter, provided that it is properly engineered on the basis of more complete measurements. One can be very badly fooled with this type of meter if it is not properly checked.

Loudness Summations. A valuable sound measurement is obtained by employing a soundmeter designed to weight the various frequencies according to certain experimental data on ears, and to measure all components of the sound simultaneously. This reading is usually called the "total noise," and experiments show that on the whole such readings agree very well with the average loudness judgments of a number of observers under favorable conditions for listening. A "total-noise meter" is therefore a very valuable instrument, but, as will be shown immediately, it is not sufficient for most problems of machine-noise reduction.

The human ear is a very remarkable instrument. Among its many peculiar characteristics we are particularly concerned with its marvelous ability to distinguish certain sounds in the presence of other and much louder sounds. In a surprising number of cases it is found on measurement that we are concerned chiefly with sounds which may contribute but slightly to the "total noise."

If the loudness of a sound is varied without changing its quality, as, for example, by changing the volume control on a radio or phonograph, ordinarily the energy must be changed

TABLE 1 RELATIONS BETWEEN SOUND ENERGY, SOUND PRESSURE, AND DECIBEL LEVEL FOR THE SUM OF TWO INDEPENDENT SOUNDS OF VARIOUS ENERGY RATIOS

ASSUMED VALUES FOR SOUND A

Energy = 1×10^{-3} erg per sec per sq cm
Pressure = 0.2 dyne per sq cm
Decibel level = 60 db above 1000-cycle threshold

Sound B: Assumed energy, ergs per sec per sq cm	Sound B: Corresponding pressure, dynes per sq cm	Sound B: Corresponding db	Computed Sum of Sounds A and B: Energy, ergs per sec per sq cm	Computed Sum of Sounds A and B: Pressure, dynes per sq cm	Computed Sum of Sounds A and B: Decibels	Increase above sound A, db
1.0×10^{-3}	0.20	60	2.0×10^{-3}	0.282	63.0	3.0
0.5×10^{-3}	0.141	57	1.5×10^{-3}	0.244	61.8	1.8
0.25×10^{-3}	0.100	54	1.25×10^{-3}	0.224	61.0	1.0
0.10×10^{-3}	0.0632	50	1.10×10^{-3}	0.211	60.4	0.4
0.05×10^{-3}	0.0446	47	1.05×10^{-3}	0.205	60.2	0.2
0.01×10^{-3}	0.0200	40	1.01×10^{-3}	0.201	60.02	0.02
0.0	0.0	..	1.0×10^{-3}	0.20	60.0	0.0

[2] The decibel is a unit much used in the field of sound measurement for expressing sound energy, because it agrees quite well with the way the human ear estimates loudness. On the average, one decibel represents about the smallest change of loudness which the ear can detect. Practically all of the available soundmeters are calibrated in decibels. Technically it is defined as:

$$db = 10 \log_{10} (E/E_0)$$

where "db" represents the number of decibels between the given sound of energy E and the reference sound level E_0, which latter is usually taken as the faintest sound that the average ear can detect.

by about 25 per cent (1 db) before the change can be detected. On the other hand, if a new sound is introduced, its presence will ordinarily be noted when its energy is about 1 per cent of the total, and it will be very noticeable when its energy is only 10 per cent of the total. Consequently, 10 per cent changes in total sound energy are often very important if they are due to changes in only one of the components, while changes of 25 per cent are negligible if all of the components are affected. Since a total-noise meter gives a measure of the total energy, it cannot distinguish between these two types of change and therefore its practical value is greatly limited in certain work.

This may be illustrated numerically as follows: Assume that a sound A has a pressure of 0.2 dyne per sq cm (about the level of ordinary speech). As shown in the Appendix, the corresponding energy and decibel level are:

Energy = 0.001 erg per sec per sq cm of wave

Decibel level = 60 db above 1000-cycle threshold.

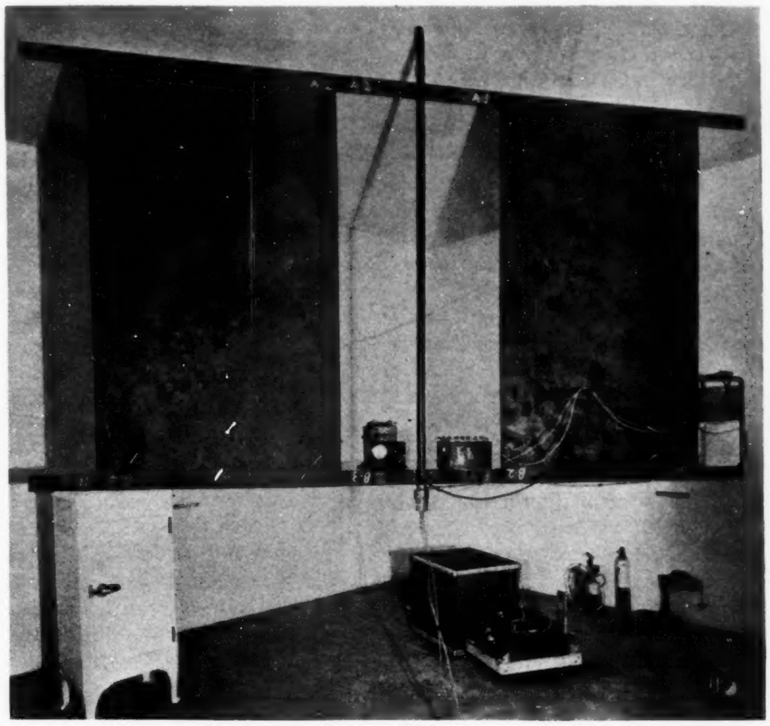
To this sound A let us now add a second sound B, of different frequency, whose level we shall vary. Table 1 shows the results of such a combination. It will be observed that the energies of the two sounds add directly, while the pressure and decibel level are computed according to the formulas given in the Appendix.

As mentioned above, experiments have shown that ordinarily the presence or absence of sound B would be detected even when it was 20 db less than sound A (1 per cent of the energy), and that it would be very noticeable when it was within 10 db of sound A. On the other hand, it would change the "total noise" by less than 1.0 db as long as it was more than 6 db smaller than sound A, and the change would be only 3 db if the two sounds were equally loud. The effect is even more striking if there are several sounds of about the same loudness. Suppose, for example, that we have a single initial sound of level 60 db and add to it five other sounds each of which is 50 db; the level of the six combined sounds is then only 61.8 db. If four sounds are added instead of five the level will be 61.5 db. In other words, a change of one of the components of a sound which may be very noticeable indeed to the ear often produces a change in the "total noise" which is much less than the uncertainty due to wave patterns or to fluctuations in the intensities of the other components which cannot be detected by the ear.

Consequently the two fundamental difficulties of sound measurement, namely, the physical distribution of the sound pressures and the method in which the human ear "adds up" loudness, result in a combination which makes it very difficult to deal with many noise problems with a total-noise meter. The obvious remedy is to use an analyzing soundmeter which can focus its attention on particular parts of the sound. This introduces additional equipment, and increases the time of observation due to the necessity of maintaining speed, adjustment of tuning, and the additional number of readings. This is a very real drawback in the case of routine inspection, and the author does not foresee a very great field for it with general-purpose equipment.

ADVANTAGES OF METER MEASUREMENTS OF SOUND

After this rather formidable list of difficulties of sound measurement, the prospective user of sound-measuring equipment may very properly ask himself, "Why go to all this bother? My product will probably be judged by ear finally, so why not inspect it by ear?" This is a fair question. It is doubtful if many sounds can be measured by instrument which cannot be heard by ear, and the ear is also very good for noticing sudden changes in quality. If favorable conditions for listening are available, and if the changes can be made quickly, there is little doubt that a good ear is of much more value than a poor soundmeter. On the other hand, a good soundmeter possesses a number of fundamental advantages over the ear, and



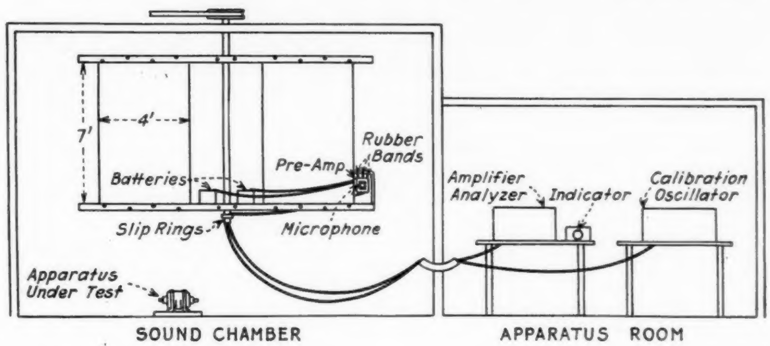


FIG. 2 A RAPID AND CONVENIENT MEANS OF AVERAGING WAVE PATTERNS IN USE IN THE ENGINEERING RESEARCH LABORATORY AT THE UNIVERSITY OF MICHIGAN

(The large sheet-iron reflector is rotated to "stir up" the sound-wave patterns and to move the microphone through a considerable path. The accompanying short-time fluctuations in sound are averaged by the use of a slowly responding indicator meter.)

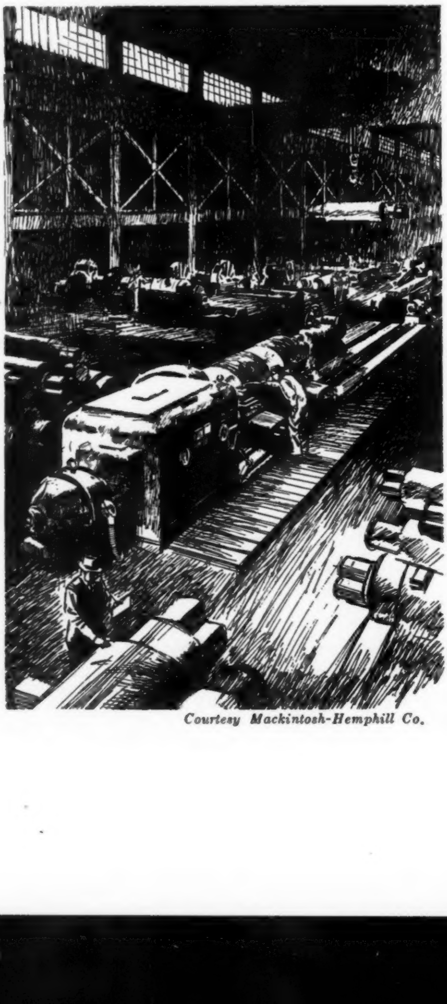
most of the difficulties encountered in the measurement of sound by meter are inherent in the sound itself, and apply with equal force to listening by ear.

Holding of Limits. The ear cannot be depended upon to hold limits to within 5 to 10 db for more than a few minutes. This can be so easily proved and is so well known that it does not warrant further discussion here. Since most practical quieting experiments require time, the "before" and "after" conditions cannot be switched back and forth at a second's notice and the ear must be depended upon to remember how loud the sound was, and the results are far from satisfactory. In holding inspection limits the same difficulty is encountered. Properly taken instrumental measurements can always be referred to an absolute standard.

Numerical Data. The human ear does not give numerical data on the amount of change produced. In many cases the amount of quieting obtained by a given change is less than the sample-to-sample variation in the product. The ear can hardly hope to compare average noise before with average noise after, but this can easily be done with meter measurements. As explained previously, if there are four or five approximately equal sources of sound, stopping them one at a time produces very little change in the total loudness, so that it may be impossible to be sure of the change by ear. If the differences are measured by meter, the effects of several simultaneous changes can be estimated from individual experiments.

Finding the Causes of Noise. An analyzing soundmeter yields a large amount of information concerning the causes of the noise. The frequencies of the individual components can be accurately determined, and these can be identified with the various parts of the mechanism such as gears, shafts, etc. Resonances or critical frequencies of various parts can be located, the character of the sound determined, and the various components traced to different parts of the machine. In case there are a number of components of essentially the same pitch, this is often very important. In some cases the nature of the defect can be determined as well as the source. This feature of sound measurement supplies information which cannot be arrived at by ear.

Indication of Next Move in Quieting Problems. In many cases one is not sure just what has been accomplished by the last quieting experiment, nor what should be done next. Very often the cause of the undesired noise is obscure, and in a surprisingly large number of cases different observers are listening to different things. It is almost impossible to describe a sound to some one else so that he will recognize it. This difficulty can be eliminated by listening through an analyzer to the different sounds. Data on frequency analyses of various samples of machines showing different types of noise are almost certain to show up differences which will determine the undesirable sounds and suggest experiments for their reduction. By keeping track of the comparatively minor effects of a number of changes, a large overall reduction can be effected by combining the results of the individual tests. Such a procedure would be very difficult, if not altogether impracticable, by ear.



Courtesy Mackintosh-Hemphill Co.

SUMMARY

Good equipment for measuring sound pressures is the first requisite for successful sound measurement, but even the best of equipment will yield results which are perfectly correct but meaningless for practical purposes unless the conditions of testing are properly arranged. Due care must be taken to average the effects of wave patterns and similar variables, and to take such precautions that the uncertainties due to these variations do not obscure the effects which it is desired to measure. The peculiar manner in which the ear adds up sounds often makes this very difficult, and in order to obtain practical results on machinery-quieting problems it is almost always essential to use analyzers or similar equipment which will allow the various components of the sound to be measured separately.

The use of such sound measurements not only makes it possible to obtain numerical data on the sound so that comparisons can be made over long periods of time, but it furnishes a great deal of information concerning the sources of the noise, often indicates something of the nature of the defect which produces it, shows the sounds whose reduction will produce the greatest effect, suggests methods how this may be accomplished, and permits the individual study of changes which are comparatively small in themselves but which, taken together with other similar changes, produce a large overall effect. All of this information is either very difficult or impossible to obtain by ear. In addition to such general uses it appears that there is a considerable field for special-purpose sound-measuring equipment for the rapid noise inspection of routine production. The latter equipment should be engineered for the particular installation to make sure that the proper quantities are being measured with sufficient accuracy for the job at hand.

APPENDIX

In a free plane sound wave the energy and the pressure are related by the expression $E = p^2/41$, where E is the energy flow in ergs per second per square centimeter of wave front, and p is the root-mean-square sound pressure measured in dynes per square centimeter.

If the energy flow corresponding at the 1000-cycle threshold is taken as 1×10^{-9} erg per sec per sq cm (1×10^{-16} watt per sq cm), as given by H. Fletcher of The Bell Telephone Laboratories at the May, 1932, meeting of the Acoustical Society, decibels above the 1000-cycle threshold are computed by means of the following formula:

$$\text{db} = 10 \log_{10} \frac{E}{1 \times 10^{-9}}$$

where E is the energy flow of the sound in question in ergs per square centimeter per second, and "db" is the decibel level of this sound above the 1000-cycle threshold. The values in Table 1, which gives the relations between sound energy, sound pressure, and decibel level for the sum of two independent sounds of various energy ratios, were computed from these two relations.

WILL THE USE OF ALCOHOL FOR FUEL BENEFIT THE FARMER?

Photo by Nesmith

Alcohol-Gasoline Mixtures *as* MOTOR FUELS

SOMEWHAT more than twenty years ago when it was felt that the petroleum resources of the United States and of the World were fast dwindling to a point where their use would have to be limited to naval vessels and lubrication purposes, suggestions were put forward looking to the substitution of other fuels for gasoline. Among other proposals was that of using alcohol. Under the supervision of Dean R. H. Fernald, then engineer in charge of the gas-producer section of the technologic branch of the United States Geological Survey, an investigation of liquid fuels was conducted that resulted, in 1912, in Bureau of Mines Bulletin 43, by R. M. Strong and Lauson Stone, entitled "Comparative Fuel Values of Gasoline and Denatured Alcohol in Internal-Combustion Engines."

Today, in Czechoslovakia, a blend of 80 per cent of gasoline and 20 per cent of alcohol made from potato starch is required by law as a substitute for straight gasoline as a means of promoting the potato industry. In the United States, in certain agricultural states, serious proposals to enforce similar requirements in order to provide a use for overproduced grain products have been made; and a bill along these lines was introduced during the last session of the Seventy-Second Congress by Representative W. E. Hull, of Illinois, who promises to reintroduce it in the present session. Representatives Dirksen and Christianson have, on March 27, introduced bills H.R. 4215 and H.R. 4216, respectively, in which it is proposed to arrange taxes on straight gasoline used for motor fuel in such a way as to force the use of blends with alcohol manufactured from agricultural products.

These brief references serve to emphasize the two principal reasons for the use of alcohol and alcohol-gasoline mixtures for fuels: (1) As a substitute for straight gasoline where the latter fuel must be imported or is rendered expensive because of failing supplies of petroleum; (2) For the promotion of agriculture by making alcohol an element of the motor-fuel supply, thereby assisting grain prices and a favorable balance of trade.

Arguments for and against the use of blends of alcohol and gasoline fall into many categories, political, economic, and technical. It is possible at this time to mention only some of the economic and technical problems involved.

From an engineering point of view a considerable amount of information on the burning of gasoline-alcohol mixtures in internal-combustion engines is available. From this it would appear that the blend can be used providing the alcohol is anhydrous and providing further that certain comparatively minor adjustments are made to the motor to which it is to be supplied. It does not appear definitely as yet that an alcohol-gasoline mixture can be used with complete satisfaction interchangeably with a straight gasoline mixture. On the other

hand, it is claimed that the addition of alcohol to gasoline reduces the knock tendency of the latter.

The economic problem may be considered from two points of view, namely, the cost of fuel and extent to which the use of an alcohol-gasoline blend is likely to assist agriculture. As regards the former, attention is directed to the fact that alcohol as produced by the standard method of conversion of starch by fermentation necessarily carries with it from 4 to 6 per cent of water, and the dehydration of the alcohol to the point where it can be used in an internal-combustion engine is somewhat expensive. True, a new distillation process using benzene has recently been developed that produces an anhydrous alcohol, but the process is applicable only on a large scale and even then the cost is comparatively high. In addition to this the additional costs of processing and transporting the alcohol and of blending it with gasoline must be considered. It is to be expected, therefore, that alcohol-gasoline mixtures will cost more per gallon than straight gasoline and will give slightly fewer miles per gallon. The problem of the taxes on alcohol and gasoline is political in nature, but has economic effects. It concerns the more important question of the extent to which the use of alcohol-gasoline mixtures help the farmer in whose interest their required use is proposed. As a matter of fact, both gasoline and alcohol are heavily taxed today, so that it would be necessary to make such adjustments as would neither rob taxing agencies of their present revenue nor increase the cost of motor fuel to a point where the farmer paid more for it than his grain crop was worth otherwise.

The legislature of the state of Iowa recently held a public hearing on the subject of the use of alcohol-gasoline mixtures. The arguments against the use of alcohol presented at this hearing are being distributed in the form of a bulletin by the Illinois Petroleum Marketers' Association, of Springfield, Ill. Among the arguments presented it is alleged that the increased cost of the gasoline-alcohol mixture would militate against the use of motor cars generally, that the storage and handling of alcohol blends is difficult and expensive because of the tendency of alcohol to settle out, especially when even small amounts of water are present, and particularly that the cost of converting cereals, such as corn, into alcohol, including the cost of the raw material, is so high that it would make the fuel expensive.

As to the technical problem of manufacturing the alcohol, several processes have been developed lately that are said to produce alcohol at prices considerably below those at which it can be produced from starches. Among these may be mentioned a process for the manufacture of alcohol from coke-oven gas; a process which has been developed by the Petroleum Chemical Corporation and now jointly controlled in modified form by the Standard Oil Company of New Jersey and the Barnsdall Corporation, in which alcohol is made from oil, and the French Prodor process in which wood cellulose is converted into glucose sugar by the use of acids, and the glucose into alcohol by fermentation. The practical feature of the Prodor process is that, contrary to previous practice in which hot diluted acids were employed, cold concentrated acids are used and effect a complete conversion of the cellulose to glucose in a form which is fermentable. The yield is about 25 liters of 100 per cent alcohol per 100 kg of wood. Hydrochloric acid is employed because it can be recovered from the solution by distillation and used over and over again. Practically any kind of wood can be used providing it is cut into pieces small enough to be readily acted upon by the acid.

Another method of producing alcohol from cellulose is by the action of various microorganisms. This was particularly referred to by Sir Charles H. Bedford, formerly chemical adviser to the Government of India, in his paper before the First World Power Conference (Section N, No. 417). Still another process has been invented by Doctor Bergius and has been under development by the International Sugar and Alcohol Co. in a plant at Vernier, near Geneva, Switzerland. In addition, alcohol may be manufactured from coal by the Bergius hydrogenation process.

In Russia alcohol has been produced on a laboratory scale from ethylene, which is itself produced from crude oil.

Sweden. The subject of use of alcohol as fuel has been under investigation in Sweden since about 1911. During the War, Sweden was completely cut off from foreign supplies of gasoline and was forced to use native alcohol, under the handicap of not being able to purify it properly because of restrictions created by a shortage of the necessary chemicals. The alcohol was therefore diluted with benzol, turpentine, acetone, wood alcohol, etc. This created an impression that alcohol was an inferior fuel for motor vehicles. However, at least a few engines were properly adjusted for alcohol. Today, the Swedish practice is to employ from 75 to 80 per cent gasoline, the remainder being alcohol, with the proviso that the latter shall be practically free from water. This mixture makes an excellent fuel. The trouble is that the production of proper grades of alcohol in Sweden is lagging, as the cellulose manufacturers have been slow to equip their by-product alcohol plants with machinery for the production of industrial alcohol. Attention is called to the fact that the Swedish alcohol is not produced from agricultural products but is a by-product of cellulose manufacture.

Australia. The subject of denaturants for fuel alcohol was carefully considered in a report by the Commonwealth Advisory Committee on Science and Industry presented to the Australian Government in 1918. For denaturants this report recommends tar-oil distillates as being cheap, effective, and having no corrosive action on valves or cylinders.

France. In France soon after the war the Department of Inventions investigated the subject of alcohol-gasoline mixtures at the Laboratory of the Technical Division of the Artillery, at that time under the command of Colonel Nicholadot, well-known chemist and scientist. The report was to be strictly secret, but the information leaked out in 1922. The report came to the important conclusion that the minimum temperature at which the homogeneous system of alcohol, American gasoline, and benzol may exist rises very rapidly with the water content of the alcohol. This immediately suggests a practical point, namely, that containers in which such mixtures are produced should be either carefully dried or rinsed in alcohol, the latter being then recovered. For an alcohol for a given degree of strength the minimum temperature of homogeneity is lower the greater the proportion of alcohol, the lighter the gasoline, and the less the content of higher homologues (toluene, etc.) in the benzol.

It would appear, therefore, that technically there is no doubt that gasoline-alcohol mixtures can be successfully burned in a modern internal-combustion engine. Whether such a mixture will make the motor as responsive to sudden changes of load as it is with straight gasoline remains to be seen, but probably it can be done. In a country like the United States the cost of operation per mile will be somewhat higher with the gasoline-alcohol mixture than with straight gasoline. The question as to whether growers of starches, such as cereals, potatoes, tapioca, etc., or of sugars, such as molasses, will profit from the adoption of alcohol as a subsidiary fuel will depend on whether synthetic and artificial alcohol, in particular alcohols obtained by hydrogenation or by treatment of cellulose, can be produced for a price that will be lower than that of the various types of fermentation alcohols, particularly in view of the fact that apparently only a water-free alcohol can be used as a fuel.—L. C.

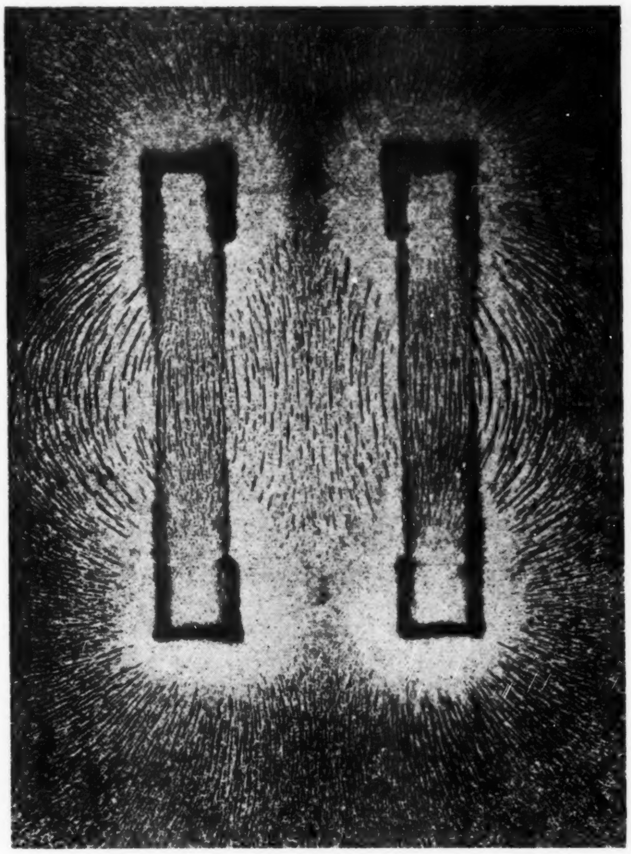


FIG. 1 THE MAGNETIC FIELD OF TWO BAR MAGNETS PLACED WITH LIKE POLES OPPOSITE EACH OTHER

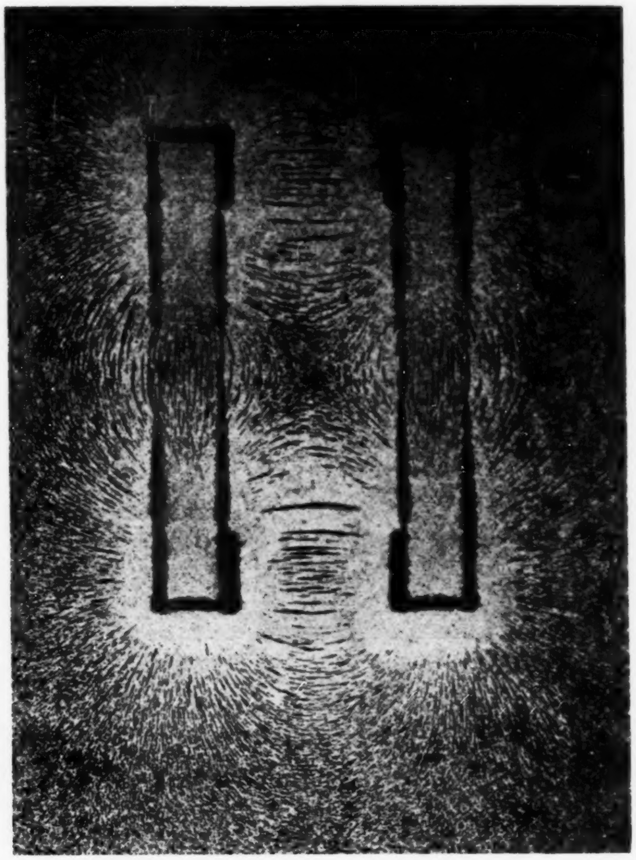


FIG. 2 THE MAGNETIC FIELD OF TWO BAR MAGNETS PLACED WITH UNLIKE POLES OPPOSITE EACH OTHER

MAGNETISM *and the* STRUCTURE *of* METALS

By FRANCIS BITTER[1]

THE surface of a metal constitutes a box which we cannot open. In order to find out what is going on inside we must be content with one of two methods of investigation: We can examine or treat the surface in a variety of ways; or we can send into it some kind of a messenger with the hope of being able to understand what he has to say when he comes out. By means of such procedures as heating, hammering, alloying, investigating with X-rays, bombarding with electrons, etc., we have learned much about the inside of a metal. We know its crystal structure. We know its chemical composition. We can harden it or soften it at will, melt it, or make it brittle. Additional knowledge is continually being sought.

During the past few years physicists have been making their contributions to this fund of knowledge in the form of an electron theory, due chiefly to Pauli and Sommerfeld. This theory is based on two assumptions, two assumptions now so well established that we might almost call them facts; the exclusion principle[2] and the wave nature of electrons. The older theories of metals which assumed that the electrons in a metal behaved like a gas of charged particles were wrong. Electrons do not obey the usual statistical laws. The exclusion principle, which states quantitatively that no two electrons can behave identically in a metal, made it possible to establish the required new statistics. Further, the old theories assumed that collisions took place between the conduction electrons and the atoms of a crystal, and that electrical resistance, for instance, was due to such collision processes. Since Davisson and Germer, G. P. Thomson, and others have established the fact that an electron in colliding with the atoms of a crystal behaves like a wave, i.e., is reflected or scattered according to optical laws, it has been possible to remodel the electron theories of

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[2] Some applications of the exclusion principle to electrons in metals are described by Professor Karapetoff in MECHANICAL ENGINEERING, April, 1933.

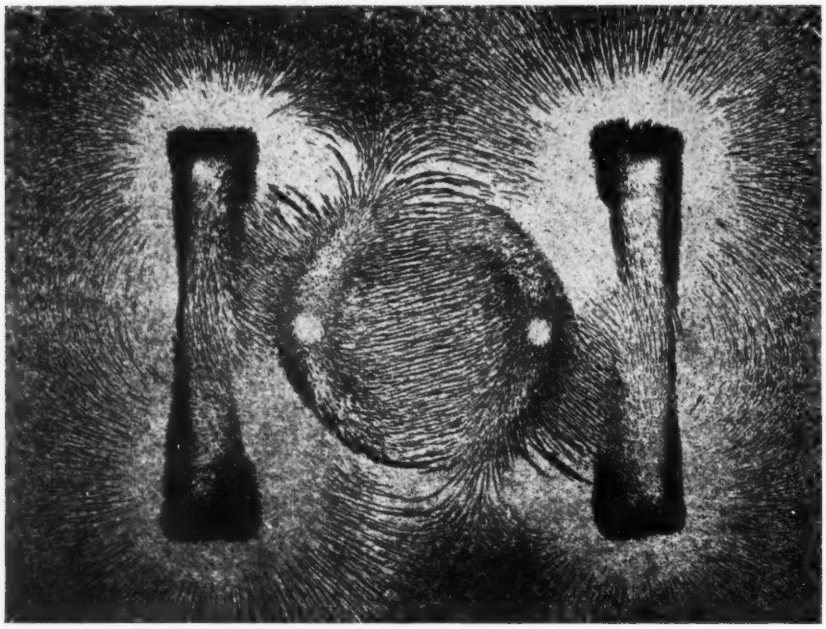


FIG. 3 THE COMPLICATED FIELDS DUE TO TWO BAR MAGNETS WITH A MAGNETIZED RING BETWEEN THEM (NOTE ESPECIALLY THE CLEAR MANNER IN WHICH TWO HOLES IN THE RING MAY BE DETECTED)

(Photographs by T. R. Watts of the Westinghouse Research Laboratories.)

metals. By making use of the theory of diffraction, the effect produced by a ruled grating on a light beam can be calculated. Similarly, it is possible to calculate the effect of a crystal lattice, which is essentially a three-dimensional grating, on moving electrons. The theory is mathematically complicated and has therefore been developed only in a very simplified form, namely, without properly taking into account the forces which the electrons exert on each other. Even so, the theory has been successful in explaining the outstanding electrical, magnetic, and thermal properties of metals, such as electrical resistance, thermal conductivity, specific heats, the Hall effect, and lately also the rectifying properties of oxide layers.

But there is a group of phenomena that is not at all understood. The difficulty seems to be centered on the interaction of the metallic electrons with each other, which, as has just been pointed out, has so far been neglected in the theories. Of these unexplained phenomena, the physicists seem most interested in supraconductivity, the name given to a property that some metals acquire at very low temperatures, namely, the loss of all traces of electrical resistance. Students of the solid state could list various others. What, for example, causes the geometrical and regular spacing of etching figures on single crystals? How can a mere trace of impurity, 0.001 per cent of carbon in a sample of iron, completely change its magnetic properties, as if the sample had somehow been poisoned? What is responsible for the shape of snow flakes?

A further attack on such problems is most important to physicists and to engineers. Is the present theory of metals, if properly applied, adequate to explain these apparently mysterious phenomena, or is the addition of some new concept necessary? Professor Bohr, and independently Professor Kronig, have suggested that the free electrons of a supraconducting metal form a lattice within a crystal. Professor Zwicky has suggested a block structure in solids. While the theorists are making their calculations there is much for the experimentalist to do. A most important and interesting problem is to discover what structures actually exist in crystals, apart from the well-known atomic lattice structure. It was in the hope of finding some such structure in magnetic materials that a method was worked out for investigating the distribution of magnetism along the surface of ferromagnetic materials. The remainder of this article consists of a description of results obtained by the application of this technique.

THE USE OF MAGNETIC POWDERS FOR STRUCTURAL INVESTIGATIONS

Magnetized bodies are surrounded by magnetic fields, and the shape and strength of these fields depend on just how the bodies under discussion are magnetized. A most convenient method of observing the field due to a magnet is to cover it with a paper or other smooth surface on which a magnetic powder (iron filings, for instance) is sprinkled from a height of a few inches. Patterns like those shown in Figs. 1 and 2 are obtained. The direction of the black lines in the photographs indicates the direction of the magnetic field. A similar method can be used to detect holes in a magnetic medium, as is shown in Fig. 3, which represents the field due to a magnetized ring situated between two bar magnets. The ring is pierced by two holes, which are plainly visible. Similar effects are obtained when gas bubbles or other fairly large faults are present in a magnetized material. The procedure here illustrated has been found useful in testing welds, as bad welds containing holes produce magnetic-powder patterns that differ from those produced by good welds.

FIG. 4 SLIP LINES AND A GRAIN BOUNDARY IN SILICON STEEL AS REVEALED BY MAGNETIC-POWDER DEPOSITS

By refining the method it has been found possible to detect much smaller structural imperfections than bubbles and holes. In Fig. 4, for example, is shown the deposit arrangement obtained on slip lines and a grain boundary. The sample, an annealed strip of iron containing 4 per cent Si, was given a fairly large reduction in a rolling mill.

The mechanism producing the deposits shown in the various figures differs from case to case and may sometimes be rather

FIG. 5 GRAIN BOUNDARIES AS REVEALED BY MAGNETIC-POWDER DEPOSITS

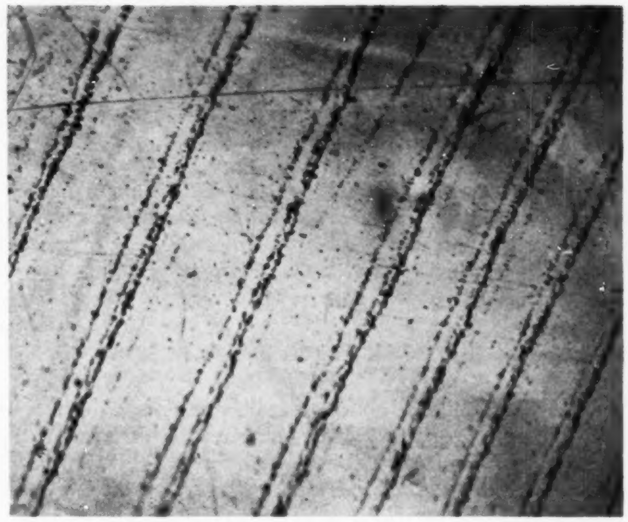


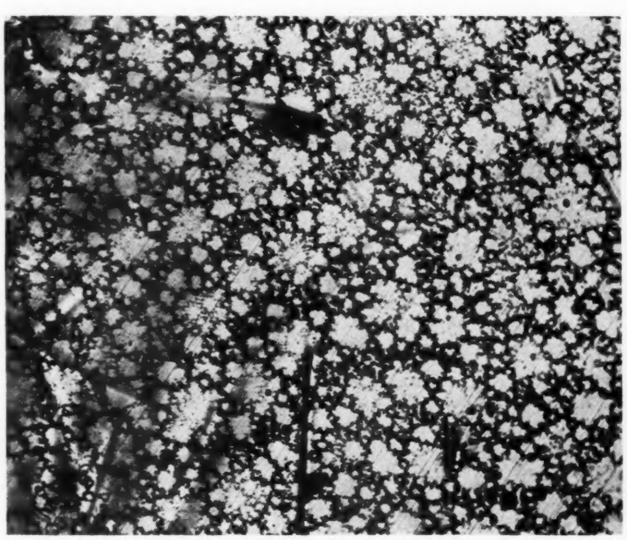
FIG. 6 NEW STRUCTURAL FEATURES ON A SINGLE CRYSTAL OF NICKEL REVEALED BY MAGNETIC-POWDER DEPOSITS × 100

involved. Suffice it to say that in the examples shown in Figs. 4 to 8, inclusive, the deposits show local concentrations of the magnetic field just above the surface of the metal. These local changes in field can be produced only by corresponding changes in intensity of magnetization along and within the surface of the metal, and this change of magnetization, in turn, implies a local change in the state or structure of the material. It is not at present possible to state what atomic or electronic rearrangements accompany or produce the magnetic inhomogeneities.

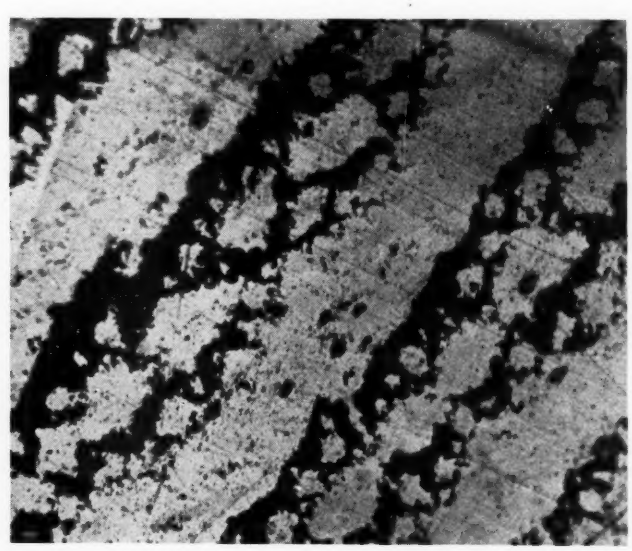
For the observation of small effects it has been found desirable to use a rather fine powder suspended in a liquid. For this purpose magnetic Fe_2O_3 suspended in a liquid having low viscosity, such as alcohol or ethyl acetate, has been found eminently satisfactory. Ether is not good as a medium for the suspension as its rapid evaporation (boiling) prevents the suspension from settling uniformly. The procedure in using a suspension is merely to apply a few drops (the proper concentration having been determined experimentally) to the surface to be examined. The powder settles almost at once in those regions where the magnetic field is strongest. The proper experimental conditions must be found separately for each type of sample to be investigated. Besides the suspension itself, the proper choice of intensity and direction of magnetization is most important to the success of an experiment.

Fig. 5 shows the deposit obtained on a polished sample of 4 per cent Fe-Si alloy. The grain structure is plainly visible. In this illustration the magnetization is in the horizontal direction. It is interesting to note that grain boundaries more or less perpendicular to the direction of magnetization seem to show up more strongly than boundaries parallel to the direction of magnetization. This is a peculiarity of the method.

(*Continued on page 336*)



(Fig. 7 Unmagnetized ×100)



(Fig. 8 Magnetized ×200)

FIGS. 7 AND 8 NEW STRUCTURAL FEATURES ON AN UNMAGNETIZED AND ON A MAGNETIZED SINGLE CRYSTAL OF HEXAGONAL COBALT AS REVEALED BY MAGNETIC-POWDER DEPOSITS

The Fermi-Dirac Statistical Theory of GAS DEGENERATION—II

With Some Applications to Electronic Phenomena in Metals

By VLADIMIR KARAPETOFF*

V—SOME PROPERTIES OF A DEGENERATE ELECTRON GAS IN A METAL

QUITE a number of well-known phenomena in metals may be explained by assuming a piece of metal to be "permeated" by electrons forming a so-called electron gas. For example, the electrical conductivity of a metal becomes immediately intelligible as due to an actual drift of electrons within it under the influence of an applied voltage. The electrons are attracted to the positive pole of the battery and are repelled by the negative pole. The thermal conductivity may be explained as a similar drift of the kinetic energy associated with the electrons within a piece of metal away from the source of heat. Here, however, there can be no actual drift of electrons, since this would result in an electric current. It is sufficient to assume that the average kinetic energy of the electrons increases with temperature. Then the thermal conductivity of a metal may be imagined to be due to "electronic convection," similar to "molecular convection" in an ordinary gas.

By assuming that the density, and consequently the "pressure," of the electronic gas within a metal depends upon the number of atoms per unit volume, some contact phenomena between two metals may be explained, at least qualitatively. Thus at a contact surface a voltaic difference of potential may be expected to be brought about by itself, due to an interchange of slower for faster electrons (and vice versa) between the two metals. Similarly, if two adjacent portions of a homogeneous metal bar are kept at different temperatures, there must be a resultant electronic pressure (difference of electric potential) between the two. If now an electric current is sent along such a bar, the heat liberated in its individual portions will not obey the usual Joule's law. This departure is known as the Thomson effect. Thermoelectric currents may be similarly explained by differences in the kinetic energy of the electron gas.

Assume that the electronic gas is kept within a piece of metal by the retarding effect of some sort of wall or barrier, such as an intrinsic electric potential. Various kinds of electronic emission may then be explained by assuming that a suitable external agent may overcome this wall. For example, some metals emit electrons under the influence of incident light. Such a "photoelectric" effect is said to be due to the energy communicated by the light to some electrons just behind the surface, accelerating them past the barrier. Electrons may also be pulled out of a metal by an applied voltage which modifies the barrier voltage, causing a corona or glow discharge. When a piece of metal is brought up to a high temperature, the kinetic energy of the fastest electrons is increased sufficiently to overcome the restraining potential, and the so-called thermionic emission of electrons results.

Even the slight magnetic properties of alkali metals may be explained by the presence of an electron gas which pervades the metal. It is sufficient to assume that each electron is spinning about its axis and thus forming an elementary magnet. An externally applied magnetic field orients these small magnets; on the basis of the Fermi-Dirac statistics it may be shown that a residual magnetic susceptibility results. So long as the existence of such an electron gas remains a working hypothesis, certain assumptions have to be made about its properties. An assumption of its behaving like a perfect gas proved incompatible with some experimental results. With the advent of the Fermi-Dirac statistics it has been demonstrated that such an electron gas, if it exists, must behave even at high temperatures like a *completely degenerate gas* in the sense already explained.

With this new starting point and with a few other plausible assumptions, much progress has been made in correlating the groups of phenomena just mentioned and even in accounting for some of them quantitatively. Of course, the theory is not by any means complete or satisfactory in all respects, but in view of a large amount of further research done on the basis of an electron gas obeying the Fermi-Dirac statistics, an account of the basic assumptions may not be without interest. Such an account will enable the reader to follow more advanced articles in which the underlying fundamentals are not usually explained in sufficient detail.

In describing something hypothetical, the temptation is to use images borrowed from the visual world, in this case to draw a "picture" of vibrating atoms of a metal, with free electrons darting to and fro in the intervening space. Yet there is always a danger in picturing such entities as electrons and atoms too realistically, especially in view of the modern wave theory of matter. It is therefore preferable to resort to a set of individual concepts or ideas correlated into a coherent whole, rather than a set of things arranged into a picture. The description below is undertaken in this sense and the "picture" terms should not be taken too literally.

(*a*) *Atoms*. For the sake of simplicity, envisage a piece of alkali metal (lithium, sodium, potassium, etc.) in the solid state. A discussion on the basis of such metals is easier because they are strictly monovalent and electropositive. Their atoms are supposed to possess just one loose electron in an elongated elliptical orbit, an electron which can be readily detached, thus converting the atom into a positive ion with a structure similar to that of an inert gas (helium, neon, argon, etc.). The atoms of such a metal are assumed to form a regular space lattice, with a spacing readily computed from an analysis of X-ray diffraction patterns. The nature of the cohesive force which keeps these atoms at fixed distances in the solid state is not known and will be thought of in this discussion only conceptually.

Each atom is assumed to oscillate irregularly about its mean position, which accounts for the temperature of the metal and the heat energy stored by virtue of its specific heat. The intensity of oscillations is increased with the temperature, and

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the amplitude, frequency, and the length of path may be thought of as being functions of the temperature.

The loose valence electron is assumed to possess much more freedom in its motions than the rest of the atom. In fact, the electron gas will be considered as consisting of these valence electrons, the remaining portions of the atoms (that is, the positive ions) forming the metal lattice proper. Just how far these "free" electrons are really free is impossible to tell; perhaps they can form transient attachments to the positive ions past which they are drifting. The electric force must be imagined to possess very strong peaked maxima near the positive ions, with flat minima in between, so that a free electron should be considerably affected in its motion when approaching a positive ion.

(*b*) *Electrons*. In an alkali metal the number of free electrons is assumed to be equal to that of the atoms since they are simply valence electrons detached from these atoms. With this assumption the total electric charge on a piece of metal is equal to zero, as is to be expected. With more complex metals of the second and the third group in the periodic table, the number of free electrons should perhaps be assumed equal to a small multiple of the number of atoms. At any rate, the assumption that there are as many free electrons as atoms is a natural although not inevitable postulate.

The number of atoms in a piece of metal is vastly greater than that in an equal volume of material gas. Therefore, the electron gas in a metal must be conceived of as possessing thousands of times the number of discrete particles per unit volume as compared to usual gases. This fact, together with the fact that the mass of an electron is only $^1/_{3680}$ of that of the lightest molecule known (hydrogen), leads to the conclusion that the electron gas is highly degenerate even at fairly high temperatures, as will be explained.

(*c*) *The Electron Gas Is Degenerate*. For a material gas, under practically any conditions realizable in a laboratory (without going to extremely low temperatures and high pressures), the Fermi-Dirac statistics leads to results indistinguishable from those of the classical kinetic theory of gases. Referring to Equation [14], the coefficient α must have a large positive value if the gas is not degenerate, and it is only under such conditions that the formula has any physical meaning. When the temperature is reduced to a low value, such that α is no longer large compared to unity, degeneration sets in. For helium this is known to be at about 5 deg absolute.

The mass of a helium atom is about $4 \times 1840 = 7360$ times that of an electron, so that the product mT in formula [14] will remain the same for the helium gas as for the electron gas if $T = 5 \times 7360 = 36{,}800$ deg. Thus, even assuming that the number of particles N_t is the same in both cases, degeneration will begin for the electron gas at an extremely high temperature. In reality, as already mentioned, N_t for the electron gas in a metal is many times greater, thus reducing the value of α accordingly. This means that degeneration begins at a temperature much higher than 36,800 deg.

The outcome of this estimate is that at all ordinary temperatures the electron gas is completely degenerate and even at the highest attainable temperatures is nearly so. Consequently, in the theory of behavior of metals the use of Equations [19] and [20] and other relationships which apply to a completely degenerate gas are justified.

(*d*) *Specific Heat of Electrons*. The specific heat of a solid alkali metal should consist of that of the positive ions (whose mass is practically the same as that of neutral atoms) plus the contribution of the electron gas. Computing the latter in accordance with formula [20], it will be found that at ordinary temperatures the specific heat of the electron gas is of the order of one per cent of that of the atoms, and may be disregarded. This is a very important conclusion without which the Fermi-Dirac statistics would be no improvement on the classical theory. If the electron gas behaved like an ordinary non-degenerate gas, its contribution to the specific heat of the metal would be quite considerable and entirely unaccountable for by experiment. The new statistics offers a logical explanation of the fact that metals obey the law of Dulong and Petit and that the contribution of the electrons to the specific heat may be neglected. The number of electrons may be assumed to be equal to that of the atoms, or even a few times greater, and yet contribute but a little to the specific heat of the atoms themselves.

(*e*) *Electron Spin*. So far an electron has been assumed to be a negative electric charge concentrated in the form of a sphere of a certain very small radius, this sphere being endowed with a motion of translation in the inter-atomic space. The electron will now be endowed with a spin, that is, with rotation about an axis passing through the center of the sphere. Furthermore, it will be assumed that there is such a variety of velocities and directions of translations and spin that electrons can be no more than "anti-paired." This means that for an electron of a given vectorial velocity of translation and a given direction of the axis of spin in space, there is not more than one electron with the same vector of velocity of translation; this second electron must have the axis of spin anti-parallel to that of the first. This is in accord with the Pauli exclusion principle, in order not to have two or more electrons with all the quantum numbers identical.

The electron spin has been introduced in physics partly in order to account for certain complexities of spectra and the effect of magnetic field on spectra, and partly in connection with the so-called gyromagnetic rotation (phenomena involving magnetization and rapid rotation of a ferromagnetic bar). If electron spin exists, it must be taken into consideration even in the theory of the phenomena where it need not be introduced for the sake of a qualitative interpretation. Thus, for the sake of consistency, pairs of electrons differing only by the direction of the spin must be considered in the problems involving electron gas in metals. It will be shown that this assumption is helpful in accounting for the fact that the magnetic susceptibility of alkali metals in the solid state is independent of the magnetizing force and of the temperature.

The assumption of electron spin is tantamount to the assumption that each electron is an elementary magnet of definite magnetic moment. In a magnetic field, the axis of rotation of an electron is either parallel or anti-parallel to the field, and the energy of the electron is either increased or decreased by a definite amount.

When deducing the fundamental formulas of the Fermi statistics for material gases, it has been assumed that for each cell in the representative space there is either only one molecule of gas in the real space or none. For an electron gas, because of the spin, two electrons are permitted per cell, with opposite directions of rotation. Thus, if the actual number of electrons per unit volume of metal is n, only $0.5n$ should be used in the foregoing formulas deduced for a material gas. The other $0.5n$ is automatically taken care of by the additional assumption of two permissible electrons per cell. With the electron gas practically degenerate, all the lower cells are fully occupied so that two permitted electrons means two actually existing electrons. The factor 0.5 should be used before N_t in Equations [17], [18], [19], and before n in Equation [20], when these equations are applied to an electron gas.

(*f*) *Pressure of Electron Gas*. While the mechanical pressure of the electron gas does not enter directly in the present con-

siderations, the following quotation from Darrow[5] may be of interest: "The pressure P of the electron gas is related to the energy per unit volume E/V by the equation valid also in the classical theory: $P = (2/3)(E/V)$, and therefore varies like the total energy—starting from a value absurdly high at the absolute zero (hundreds of thousands of atmospheres) and increasing therefrom very slowly at first, though according to a T^2 law, as the temperature rises." This statement is simply quoted for the sake of completeness, without attempting to explain such unreasonably high computed values of pressure.

(*g*) *Electrons Conceived of as Waves*. In some phenomena, such as deflection by electrostatic and magnetic fields, electrons behave like small discrete particles endowed with a mass and an electric charge. In other phenomena, such as reflection from the surface of a crystal, they behave like waves and experience diffraction. It is generally conceded at the present time that not only electrons but atoms and ions as well partake of the properties of both material particles and some peculiar waves.

In this particular problem, it is convenient to think of electrons as both particles and waves, without ascribing too definite a picture to either concept. For example, in speaking of the electron spin, it is difficult to think of anything but a small particle. Yet, when it comes to a discussion of the mean free path (see section *h*), the idea that an electron is only a particular region in a group of accompanying waves seems to be more fruitful of results.

The principles of wave mechanics cannot be entered into here, and it will simply be stated that at comparatively low speeds which must be ascribed to free electrons within metals, the corresponding wave lengths are several times the lattice spacing of a metal crystal.

With electrons conceived of as material particles, darting to and fro, it is possible to speak of collisions between them and the metal ions forming the crystal lattice. Remembering the relative sizes of atoms and electrons, it is clear that an electron can readily pass through an atom without experiencing collision, just as a small body could pass through a solar system without a collision with either the sun or one of the planets. However, if an electron possesses some properties of a group of waves, its reaction with a positive ion of the lattice is quite different. The effect is then determined not by a single ion, but by those in the immediate vicinity as well. The phenomenon which formerly was described as a collision of two particles now becomes a scattering of a wave by a large particle (ion).

It is known from the theory of electromagnetic waves that a wave train may pass through a set of regularly spaced particles without being scattered at all, provided that the wave length is considerably greater than the lattice spacing. However, should a few of the particles become slightly displaced or be different from the rest, dispersion will immediately take place. It is also known that the presence of even minute amounts of impurities lowers appreciably the conductivity of a metal. This fact may be explained on the basis of greatly increased scattering of electron waves by the introduction of odd particles into the lattice.

(*h*) *The Mean Free Path of Electrons*. With electrons thought of as particles, the mean free path may be pictured as follows: Imagine a particular electron in its irregular motions through the metal lattice. Observe its zigzag path over a comparatively long interval of time, measure the total length of the path, and count the number of collisions with the ions. The total length divided by the number of collisions will give the mean free path. When determined over a sufficiently long interval of time, the result will be the same no matter which particular electron is singled out, because on the average the motion of all the electrons in an electron gas may be expected to be the same.

With electrons conceived of as waves, the mean free path is a measure of the rate at which a given beam of electrons, moving at a definite speed in a given direction, is dispersed into various directions by the metal ions. As Fowler puts it, "The mean free path measures the space rate of loss of directed momentum in a given electron beam."

Long free paths of electrons in a pure metal, possibly of the order of a hundred times the ionic spacing, are essential to the theory. The loss in conductivity due to slight impurities mentioned in the previous section, can then be explained by a corresponding decrease in the mean free path caused by dispersion.

Since the conductivity of all pure metals decreases with increasing temperature, it must be concluded that the mean free path also decreases accordingly. All the ions are in a state of irregular agitation which increases with temperature. The lattice may be expected to depart from geometric regularity more and more as the temperature rises, and this should increase the scattering of electron waves, with the corresponding reduction in the length of the mean free path.

On account of complete degeneration of the electron gas, its total energy is the zero-point energy, expressed by Equation [19], at all realizable temperatures. This means that the average velocity of thermal agitation of electrons, considered as particles, is independent of temperature. On the other hand, the ions vibrate more violently the higher the temperature. It is reasonable to assume that under such conditions the chance of a collision becomes greater and consequently the number of collisions per unit time increases with the temperature. Thus, on the corpuscular theory of electrons, the reduction in the mean free path with increasing temperature can also be reasonably accounted for, provided that the notion of a degenerate gas is introduced.

(*i*) *Maximum Energy of Electrons*. Dividing both sides of Equation [19] by N_t gives the average energy per particle, in this case, per electron. The factor 0.6 in that equation is the ratio between the mean and maximum values of kinetic energy. Omitting this factor, therefore, the maximum energy per electron, in other words the energy of the fastest electrons, is found to be k/θ. In this expression θ is to be computed from Equation [18], taking into account the electron spin as explained in section (*e*).

The expression k/θ is in energy units. In application to electrons, it is customary to express energy in equivalent volts, say, P'. The work done by an electron in moving from rest at a point of potential zero to an equipotential surface of potential P' is $P'e$, where e is the electric charge on the electron. If there is no electric field beyond P', the electron will continue to move at a constant velocity such that the kinetic energy is equal to $P'e$. Since e is a universal constant, the kinetic energy of an electron may be expressed in volts by dividing the energy by the charge e, in proper units. A 50-volt electron is one moving at such a velocity or with such kinetic energy as would be produced by accelerating it from rest by a difference of potential equal to 50 volts.

The equivalent voltage of the fastest electrons in a completely degenerate gas within a metal depends upon the nature of the metal. Since $1/\theta$ increases with N_t, the equivalent voltage increases with the compactness of the ionic lattice. The numerical values range from 2.1 volts for potassium to 6.0 volts for platinum. While these are quite low voltages for free elec-

[5] Karl K. Darrow, "Statistical Theories of Matter, Radiation, and Electricity," *Phys. Rev. Suppl.*, vol. 1 (1929), p. 122.

trons in a vacuum tube, they are quite high for electrons within a metal; on the classical theory the corresponding values are computed to be but small fractions of a volt.

The value of the equivalent voltage does not depend on the temperature of the metal so long as the electron gas remains completely degenerate and has the same total energy and the same distribution of velocities among the individual electrons. This fact accounts for the existence of a photoelectric threshold, rather sharp at ordinary temperatures, and for its connection with the thermionic work function.

Let a piece of alkali metal be subjected to a monochromatic radiation of such low frequency that quanta of light, impinging upon even the fastest electrons just below the surface and communicating to them their full energy, cannot accelerate these electrons sufficiently to enable them to escape through the surface. Now let the frequency of the incident light be gradually increased, thus providing individual pulses of greater and greater energy, until the limit is reached at which the fastest electrons just begin to be emitted. This is known as the photoelectric threshold. Now let the experiment be performed at a higher metal temperature. Since the speed of the fastest electrons in a degenerate gas remains the same, the photoelectric threshold frequency should be also the same, and this is found to be the case.

If electrons behaved like a perfect gas, they would participate in the thermal agitation of the metal ions, and it would require less energy to eject them at higher temperatures. The photoelectric threshold frequency would then be lower at higher temperatures. The Fermi-Dirac statistics has removed this stumbling block from the old theory.

(*j*) *Energy Distribution in Degenerate Electron Gas.* Since the electron gas is completely degenerate, as though it were at absolute zero temperature, its total energy is constant and independent of the temperature of the metal. For a real gas the range through which the total energy is constant and independent of the temperature may be only a few degrees above the absolute zero.

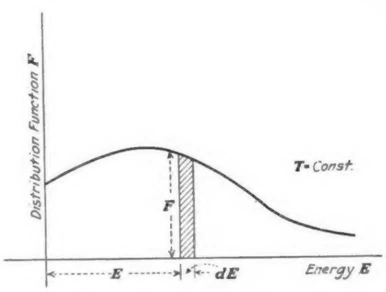


FIG. 3

The motion of a particle may be characterized either by its energy or by its momentum. Accordingly, the state of an aggregate of particles at a given temperature may be characterized by specifying fractions of the total number of particles which have energies or momenta within given limits. Let a function $F(E)$ be given (Fig. 3), where E is variable energy, and let this function satisfy the condition

$$n = \int_0^\infty F(E)dE \qquad [23]$$

n being the total number of particles per unit volume. Such a function is known as the "distribution-in-energy function." It may also be defined by the equation

$$dn = F(E)dE \qquad [24]$$

An interpretation of these equations may be seen in Fig. 3. The number of particles whose energies lie within the range between E and $E + dE$ is represented by the strip of height F and width dE. Similarly, the number of particles with energies between the values, say, E_1 and E_2, can be represented by the area of the curve between the abscissas E_1 and E_2. From this relationship, Equation [23] for the total number of particles follows directly. Function F may also be defined by the equation

$$F = dn/dE \qquad [25]$$

which follows directly from Equation [24].

For a completely degenerate electron gas obeying the Fermi-Dirac statistics, the function F has the shape shown by the parabolic curve OAB in Fig. 4. This follows directly from Equation [11]. At absolute zero and for small values of E, the exponential expression can be neglected compared to unity, so that N (which in this case is dn) is proportional to $E^{0.5}$; this gives the parabola. For values of E greater than $P'e$ [see section (*i*)], the exponential expression becomes infinitely great, and $F = 0$. In other words, the curve shows that electrons endowed with relatively large amounts of kinetic energy are more numerous than those with smaller velocities, but there are none with energies greater than a certain amount Max $E = P'e$.

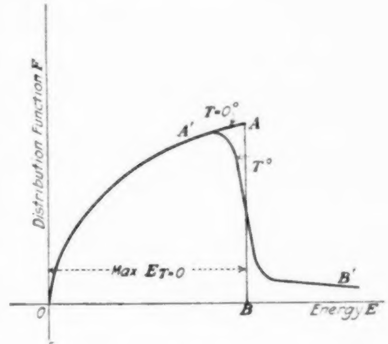


FIG. 4

At higher temperatures, the shape of the function F is more complicated because of the influence of the denominator in Equation [11], β being expressed by Equation [13]. The general character of the change is indicated in Fig. 4 by the curve $A'B'$. There are some electrons which acquire high velocities, and this fact accounts for the phenomenon of thermionic emission because of the ease with which such electrons are able to escape from the metal.

(*k*) *Distribution-in-Momenta Function.* Besides the distribution-in-energy function F, a state of a gas may be also characterized by a distribution-in-momenta function which is denoted by f, or more exactly $f(p)$, it being a function of momenta. This function may be defined as the number of gas particles (or electrons) per unit volume in the representative momentum space, and is so chosen as to refer to the total number of particles per unit volume of gas in the actual state. In other words, whatever number of particles is determined by the function f for a particular small region in the representative momentum space, that same number of particles will be found to possess momenta between p and $p + dp$ in the real space, per unit volume of gas.

It will be recalled that the momentum space has been divided into concentric shells whose radii are equal to the momenta of the corresponding particles. The volume of a shell of thickness dp at p is $4\pi p^2dp$. Hence, by definition, the total number of particles per unit volume in the actual space is

$$n = \int_0^\infty 4\pi f(p)p^2dp \qquad [26]$$

The function f may also be defined by the relationship

$$dn = 4\pi f(p)p^2dp \qquad [27]$$

which follows directly from Equation [26].

Comparing Equations [24] and [27], the following relationship is found between the distribution functions f and F:

$$F(E)dE = 4\pi f(p)p^2dp \ldots\ldots\ldots\ldots\ldots [28]$$

The relationship between the momentum and the kinetic energy of a particle is

$$p^2 = m^2v^2 = 2m(mv^2/2) = 2mE \ldots\ldots\ldots\ldots [29]$$

Hence

$$pdp = mdE \ldots\ldots\ldots\ldots\ldots\ldots\ldots [30]$$

Combining Equations [29] and [30] with Equation [28],

$$F(E) = 4\pi mpf(p) = 2\pi(2m)^{1.5}E^{0.5}f(p) \ldots\ldots [31]$$

In Equation [11], the right-hand side stands for $F(E)dE$, when $V = 1$. Multiplying both sides of Equation [31] by dE, it will be seen that

$$f(p) = (1/h^3)/[\exp(\alpha + \beta E) + 1] \ldots\ldots\ldots [32]$$

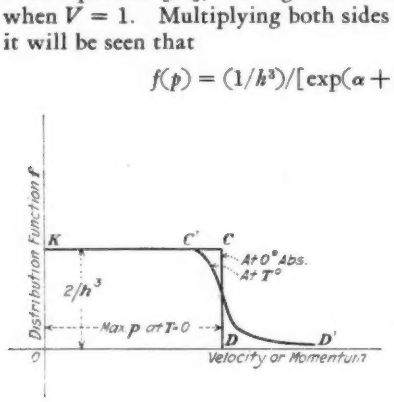


FIG. 5

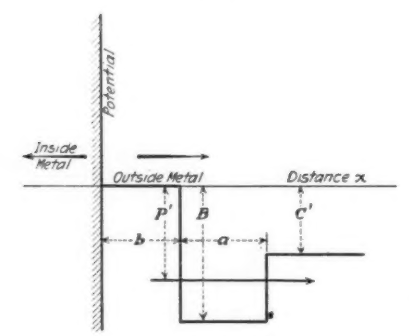


FIG. 6

In this expression, α is given by Equation [16] and β by Equation [13].

Should Equation [32] be applied to electrons, $(2/h^3)$ should be used in place of $(1/h^3)$, to account for the electron spin; see section (e). Equation [32] shows that f is a function of p^2 rather than of p, the right-hand side containing E and not p. For this reason, f is sometimes plotted to E (and not p) as abscissas.

The shape of the function f is particularly simple for a completely degenerate electron gas, because then, by the fundamental assumption, all the cells nearest the origin in the momentum space are occupied. The volume of each cell being given by Equation [1], the number of particles per unit volume in the representative momentum space is constant and equal to V/h^3. This value, by definition, is the function f, provided $V = 1$. Being independent of p, this function is represented by a horizontal straight line in Fig. 5. In application to electrons, its height is $2/h^3$, and not $1/h^3$, because of the electron spin. At very high temperatures, the degeneration is not quite complete and there are some electrons endowed with higher velocities. This is indicated in Fig. 5 by the curve $C'D'$.

(I) *Conditions at the Surface.* So far nothing has been said about the forces which prevent the free electrons within a piece of metal from escaping through its surface. Since there is no material wall to hold them, some recent writers have assumed a distribution of electric potential just outside the metal surface such as to prevent electrons from escaping (Fig. 6). Generally speaking, an electron, being attracted by positive charges, tends to "buck" a line of force, that is, it climbs to points of higher potential. Therefore, it is sufficient to assume that the space just outside the metal is normally at a lower potential than that within the metal, by an amount B greater than P', where the meaning of the voltage P' is explained under section (i). In other words, there is postulated an unknown arrangement of fictitious negative charges outside the metal surface, causing lines of force to issue from the metal outward. The electrons may then be considered as being kept within the metal either by the repulsion of these external negative charges, or because of a tendency to move against the direction of an arrowhead marked on a line of force.

In Fig. 6 negative potentials are plotted below the axis of abscissas, so that assuming the interior of the metal to be at zero potential, the postulated distribution of negative potential outside the metal surface may be described as follows: Over a very small distance b the potential is still equal to zero. Then it drops suddenly to a negative value B, greater in absolute value than the maximum kinetic energy P' (expressed in volts) of any free electron within the metal. The potential remains equal to B over another very small distance a, of the order of molecular dimensions, and then rises to a smaller negative value C', the absolute magnitude of C' being less than P'.

This somewhat artificial distribution of potential has been devised in order to account both qualitatively and quantitatively for the various phenomena connected with the passage of electrons through surfaces and surface films, particularly thermionic emission, cold discharge, and the photoelectric effect. According to the corpuscular theory of electrons, no electron whose maximum voltage is P' can escape through a "wall" of negative potential B, when B is greater than P'. It would lose all its kinetic energy and then be driven back into the metal with an energy corresponding to the voltage $B - P'$.

According to the wave theory, some electrons may escape across the wall B even when $B > P'$, provided that a is sufficiently small; some others may fail to escape even when $B < P'$. A certainty of cause and effect in the classical physics is replaced by the more modern concept of probability of occurrence. It is only when $P' < C'$ that no electrons can escape through the surface, even in accordance with the wave theory.

The amount of work required to remove a free electron at rest from the interior of a metal is known as the "work function." Let the corresponding voltage be P_0, the work itself being equal to P_0e. If the electron already possesses some kinetic energy, say, $P'e$, its velocity being normal to the surface, the required work is only $(P_0 - P')e$. The electron may be ejected by absorbing a quantum of incident radiation of minimum frequency μ_{min}, in which case there results the equality

$$h\mu_{min} = (P_0 - P')e \ldots\ldots\ldots\ldots\ldots [33]$$

In this expression μ_{min} is called the photoelectric threshold, that is, the lowest frequency at which the most easily removable electrons will just be ejected. From Equation [33] the photoelectric threshold may be computed; or else, knowing μ_{min}, either P_0 or P' may be determined.

The distribution of potential shown in Fig. 6 is only one of several for which computations have been actually performed and P_0 determined. P_0 is the line integral of the assumed field strength distribution from the metal surface outward to infinity. This distribution determines the fraction of the total number of electrons which actually escape from the metal under the given conditions of temperature and applied voltage, and this fraction is then used in applications to cold discharge, thermionic emission, etc. The thickness a of the top of the wall (Fig. 6) is, of course, also one of the factors in potential distribution which can be varied in computations, to obtain results in as close an agreement with experimental data as possible.

(*To be continued*)

The Balancing of ECONOMIC FORCES[1]

II—An Analysis of Twenty-Three Plans for Business Stabilization

FROM the more than fifty plans and programs presented to the Committee as remedies for business instability, twenty-three have been selected for analysis and inclusion in this report. The criterion of selection has been to give through the group a cross-section of the theories, principles, and methods now being actively advocated. Plans of similar origin and content with those selected were omitted because they did not contribute additional fundamental thought or method.

The Committee does not endorse, or condemn, or even express an opinion favorable or unfavorable toward any of these plans. They are presented as Part II of this Second Progress Report to show the type and quality of thinking being given to the problem of business instability, and to indicate suggested remedies and cures.

A uniform topical schedule of analysis was adopted with these headings: Classification, Author and Origin, Objective, Theory or Principle, Methods Advocated, Author's Evaluation, Status of Plan, Supporting Comments, Objecting Comments.

PLAN OF A. L. APPLETON

Classification. Wider distribution of national income.

Author and Origin. Allen L. Appleton, article in Springfield (Mass.) *Republican*, September 20, 1932.

Objective. An automatic business stabilizer, and eventually a better distribution of national income; not a revenue-producing measure.

Theory or Principle. To tax savings instead of income, thus preventing accumulation of capital and capital investments.

Method Advocated. Would establish a Federal graduated tax on personal savings, exempting modest savings. Savings defined as that portion of one's annual income which is retained in liquid form, i.e., cash or credits, or as invested. High surtaxes with exemptions including everything except reinvestment.

Author's Evaluation. Such a tax on annual savings will result in the wealthy spending more for services, luxuries, and travel, and less for investment in securities of unneeded and over-expanded industries. The result would be to put funds into the hands of the consuming masses and to increase corporation earnings, making bond interest safer, restoring dividends, and increasing the taxes derived from corporation earnings.

Anxious to avoid taxation for increasing funds for Government disbursement.

Status of Plan. Proposal only.

[1] Second Progress Report submitted January 13, 1933, to the American Engineering Council by its Committee on the Relation of Consumption, Production, and Distribution. Part I of the report, in which an analysis of 40 causes of business instability was presented, was published in the April issue.

PLAN OF ADELBERT AMES, JR.

Classification. A philosophic examination of our industrial system.

Author and Origin. Adelbert Ames, Jr., trained in law, art, and science. Research Professor in Dartmouth College. Plan published as a supplement to the Dartmouth *Alumni Magazine*, January, 1932.

Objective. To restore and continue prosperity.

Theory or Principle. The essence of life is becomingness and development, economically, socially, culturally, and spiritually. Well-being depends not on the absolute economic level, but upon a proper increase or growth. A steady flow of new developments is therefore imperative. He establishes two interesting and instructive human-activity classes, consumable and non-consumable. Thus clothing, heat, and food are consumable, while religion, art, and research are non-consumable. Labor-saving developments will liberate labor for the non-consumable activities. With the proper allocation of labor in these groups, modern productive methods present opportunity for the well-being of individual and society as never existed before.

Methods Advocated. To increase the flow of new developments in both the consumable- and non-consumable-activity fields, he cites the influence of personal and foundation benefactions and the properly directed influence of the Department of Commerce. To this he adds the possibility of new laws that would assist, through exemption from taxation all non-consumable activities, as is the case with churches and colleges. The increase of labor-saving developments in the field of consumable activities must be accompanied by expansion of activities in the non-consumable field, to be accomplished by a continuously evolving program of government, state, and municipal aid, plus action by individuals and privately owned industries, to increase the numbers employed in non-consumable activities.

PLAN OF CHARLES A. BEARD

Classification. A national economic plan, or a five-year plan for America.

Author and Origin. Charles A. Beard, writer and editor, New Milford, Connecticut.

Objective. To provide national control of production and distribution, not by communistic methods, but by control exercised through representatives of fundamental industries.

Theory and Method Advocated. A National Economic Council authorized by Congress representing the fundamental industries.

Repeal of the Sherman and Clayton anti-trust acts; industries affiliated with the council, and others approaching a high degree of concentration, to be declared national public-service enterprises subject to principles of prudent investment and fair returns.

A Board of Strategy and Planning to survey resources and productive facilities and forecast the production of consumers' and capital goods, allocating production not only to secure maximum of output within limits of increasing demand, but

also to raise the standard of living by increasing wages and reducing prices.

The Bureau of Standards to be strengthened by concentration of industrial research agencies to coordinate research, eliminate duplication of effort, and standardize essential commodities produced under the jurisdiction of the National Economic Council.

Each industry associated with the National Economic Council to become a syndicate of affiliated corporations, in the form of a holding company, with large directorial and service powers; each syndicate to have a Board of Strategy and Planning, geared into the grand Board; the syndicate to be divided into divisional or geographic corporations to be operated by corporation managers.

A separate Agricultural Syndicate to survey fertile regions, reforest sections now devoted to futile cultivation, plan new roads and power lines; to develop the most productive parts of the country. Large-scale corporate farming to be introduced where the old methods of farming are not profitable.

A Marketing Syndicate under the National Economic Council to eliminate waste in haulage and handling and to curtail the profits of middle men by establishing great storage houses and refrigeration plants, with branches.

A syndicate of exporting and importing corporations to direct trade with foreign countries to secure goods needed by the United States, control issue of foreign securities in the United States, and stop the reckless habits of financiers in making loans to irresponsible governments for unproductive enterprises. Through this syndicate a consistent influence in diplomacy could be wielded by means of economic pressure.

American diplomacy to proceed on the basis of the Kellogg Pact, recommending adherence to the World Court, full cooperation in the economic conferences and councils of the League of Nations, and cancellation of European war debts on condition that the armed forces of the world be reduced to a police basis.

Author's Evaluation. Believes nothing but a "planned economy" can in any way cope with our present ills.

Status of Plan. Proposal only.

PLAN OF CLARK-SMITH-SMITH-SOULE

Classification. Long-range planning for the Regularization of Industry.

Authors and Origin. J. M. Clark, Chairman, J. Russell Smith, Edwin S. Smith, and George Soule, Sub-Committee of the Committee on Unemployment and Industrial Stabilization of the National Progressive Conference.

Objective. "Regularization of industry" through: Increase of total production; increase of proportion of income going to majority of lower income ranges; raising the lowest wage rates; improving or eliminating the highest-cost concerns; use of reserve or insurance against unemployment; balancing productive equipment and demand; avoidance of wasteful duplication of existing facilities; maintenance of balance between, and stabilizating of, flow of savings and capital expenditures; prevention of concentrations of capital construction and inventory growth from causing basic production and sales to fluctuate unequally; stabilization of price levels; and canvassing of possibilities of latent as well as actual demand.

Theory or Principle. The introduction of "collective planning into our existing system." The making of "the best possible use of our resources." "Representation of all interests involved."

Method Advocated. National Economic Board to make nation-wide statistical fact-finding survey; initiate organizing councils for setting up permanent organizations in the various major branches of production and distribution, including finance; cooperate in process of organization, approve, disapprove, amend proposed plans, recommend new legislation and national policies affecting the economic system.

Authors' Evaluation. Hope "to mitigate or curb features of the economic system which cause disturbances to spread and intensify cumulatively; to prevent business from getting into such top-heavy condition that outside disturbances will start it on a long downward slide."

Status of Plan. Presented to Committee on Unemployment and Industrial Stabilization of the National Progressive Conference. Published in *The New Republic*, January 13, 1932.

Supporting Comments. Gives business a chance to rescue itself "with a reasonably free choice of means and methods.... under reasonable safeguards."

Objecting Comments. No absolute certainty in advance that the plan proposed will develop power enough to overcome disturbances which shake the economic system, but there is fair prospect of partial success.

PLAN OF H. C. DICKINSON

Classification. Business stabilization.

Author and Origin. H. C. Dickinson, Chief, Division of Heat and Power, United States Bureau of Standards, Washington, D. C.

Objective. (1) To end the depression; and (2) to stabilize a normal condition of prosperity and industrial development.

Theory or Principle. Crises result from an unstable relationship between capital goods and consumables. A trend away from the normal, either toward inflation or depression, is cumulative in effect. Three conditions occur:

(*a*) Inflation, when capital goods sell for *more* than their normal value based on current or probable earnings.

(*b*) Panic, when capital goods sell for *less* than their normal value based on current or probable earnings.

(*c*) Chronic depression, when there is serious unemployment, reduced income, and low prices, with capital goods selling at prices which may or may not be in line with the greatly reduced earnings.

Method Advocated. Condition (*a*) always ends in panic if uncontrolled and can be controlled by the Government through diverting to consumables a portion of the *unearned increment* of capital representing the excess of selling price over its normal value based on earnings.

Condition (*b*) can be controlled by borrowing, on short-time notes, using the proceeds to increase employment and buying power and thus allay popular fears, retiring the short-term notes by a levy against the resulting *increase* in value of securities.

Condition (*c*) can be controlled partly or wholly by the foregoing process combined, if necessary, with a universal non-selective tax used to retire the notes if the levy on increase in security prices is too onerous.

If the proposed tax is truly non-selective, by which is meant levied against all the population in proportion to their participation in the benefits of recovery, each taxpayer will have received in advance more than the amount of the tax in increased income through the process of recovery, before he is called upon to pay.

Each of these processes requires the emergency expenditure of funds for consumable goods and services, either by the Government or by private interests under governmental control. The most effective means is to keep *all* normal employees, governmental and others, at work through expenditures for wages or for goods and services. The next is to create useful new

employment of maximum value to the public, such as roads, parks, hospitals, education, and research. Relief of want and suffering should be provided from this source with proper regard to social reaction.

It is estimated that a maximum of five billion dollars would be required under condition (*c*) to actuate recovery under present conditions. This is equivalent to only the present loss of net national income for 40 days as compared with 1928–29.

It would require not over 10 per cent of the total resulting rise in security values for the next two or three years to pay the cost, or part of this might be assessed in the form of a non-selective tax on increased incomes.

Author's Evaluation. "The results, both economic and social, which would follow the proposed stabilization, offer promise for national welfare far beyond that yet attained with any degree of permanence."

Status of Plan. Suggestion of an individual.

PLAN OF WILLIAM B. DICKSON

Classification. Control of industrial operation and distribution of wages, salaries, and dividends. Democracy in industry.

Author and Origin. William B. Dickson, retired. Formerly Vice-President, U. S. Steel Corporation and Midvale Steel and Ordnance Co.

Objective. Decentralization of control of American industries. "This nation cannot endure permanently, politically democratic and industrially autocratic."

Theory or Principle. (*a*) Industrial workers are economically dependent. They differ from the founders of our nation:

(1) "In that they have no voice in the consideration of questions which affect the continuity of their employment"

(2) "When confronted by unemployment, they lack both the ability and the opportunity to find any means of providing for the maintenance of their families."

(*b*) "Decentralization of control of American industries by organized labor is as essential to the public welfare as decentralization of control by organized capital."

Methods Advocated. (*a*) Incorporation of labor organization, preferably company associations, with membership limited to employees of a corporation; company association, through shop committees, of elected delegates, to confer frequently with the management concerning mutual relations. Employees have equal representation on the board of directors.

(*b*) Establish by law "unemployment insurance funds" contributed by employer and employee.

(*c*) By Federal law require each corporation to maintain modern approved accounting system; covering all hazards as fire, depreciation, bad debts, etc., and an ample reserve for each. "Surplus" item by law should be made to read "Excess of assets over liabilities."

(*d*) The principal accounting item will be the amount paid as salaries and wages. These should be at current rates for similar service.

(*e*) Include in total cost of products the amount due capital partner, as current capital wages. This wage should be 4 per cent on actual capital invested.

(*f*) ".......profits, if any, should be divided as follows: Stock-holders, 4 per cent in addition to the 4 per cent wage; balance remaining, one-half to stock-holders and one-half to officers and employees."

Author's Evaluation. The plan will give each of the three, capital, management, and labor, "a voice in all decisions which affect vitally the general welfare of all." The worker will secure economic independence through definite plans for participation in profits and unemployment insurance.

Status of Plan Proposal only.

PLAN OF FRANK D. GRAHAM

Classification. Abolition of unemployment.

Author and Origin. Prof. Frank D. Graham, Professor of Economics, Princeton University.

Objective. Prevent unemployment during depressions by co-operative devices.

Theory or Principle. Establish an emergency production board and an emergency distributing board under the auspices of, say, the National Chamber of Commerce or the Industrial Conference Board. The boards would furnish employment and distribute products. They would operate without profit. The unemployed would produce their needs, using existing equipment. The medium of exchange would be consumption certificates—unit value, one hour of unskilled labor.

Author's Evaluation. "It is possible to deal effectively with unemployment as distinct from the broader problem of business depression on the basis of *present* knowledge." That is, he thinks the problem of unemployment can be segregated from surrounding conditions and cured independently, although he admits the difficulties.

Does not believe in planned economy and says that nothing short of that now operating in Russia can be effective in preventing depressions.

Status of Plan. Suggestion of an individual.

PLAN OF WILLIAM GREEN

Classification. Economic planning, worker security, unemployment relief, and unemployment insurance.

Author and Origin. William Green, President, American Federation of Labor, through the Annual Report of the Executive Council of the American Federation of Labor, submitted to the Annual Meeting of the Federation, on November 21, 1932.

Objectives. To check wholesale destruction of human personalities and redirect energies to restore sanity and balance in economic life, and to provide permanent channels for sustained progress.

Payment, in the right proportion, of wages, salaries, and dividends by each individual operating unit.

Advance Federal and local programs to be made promptly effective for unemployment relief.

An unemployment insurance plan which will provide for the payment of weekly benefits to unemployed workers.

Theory or Principle. Economic Planning: Fundamental changes in the technique of work and living have eliminated time and space as barriers to human intercourse and have placed the limiting factor in production outside the individual producing ability.....The basis of organization for activity in various fields must be shifted from the individual to the groups through which the individual functions.......Plans for maintaining economic balance must grow out of a unified basic philosophy and coordinated procedure to advance human well-being. National economic planning should aim at raising standards of living for lagging groups and not at a program of limitation of production with price fixing. We need to find out how best to use our capacity to produce.

Worker Security: Work is the source of our wealth. Those who invest the work of their hands and minds have a right to claim a good living from the proceeds of their investment. What every worker wants is a job and the sense of security that comes from having a dependable source of income. Life and living, in the full meaning of that term, are inseparably

associated with employment, wages, work security, the possession of a job, and the exercise of the right to work.

Unemployment Relief: Whatever degree of benefits we may derive from stabilization, we shall need to be prepared to relieve the unemployed for years to come. To meet the tragedy of unemployment in any way but giving work is failure. The lesson of the present depression shows us that we must establish adequate relief machinery.

Unemployment Insurance: The economic facts arising out of the unemployment situation make it absolutely necessary to develop and put into practice through the enactment of appropriate legislation, an unemployment-insurance plan which will provide for the payment of weekly benefits to unemployed workers.

Methods Advocated. Economic Planning: Plans for maintaining economic balance should involve the following: Steeply graduated income and inheritance taxes; constructive control of credit to finance production; recognition of the equities of workers in the industries in which they work and at least protection equal to that given financial investments; Federal agency to collect and collate data on man-hours and wage-earner income, necessary to appraise producing workers' participation in industrial progress (such an agency would provide the standards for determining economic balance); Federal licenses for corporations operating on an interstate scope, with specific requirements as to accounting; all accounts available to those interested and protective service for investors; organization of wage earners to advance their interests intelligently within industry and other relationships; legalize normal functions of trade associations.

As essential to the development of agencies for national economic planning, recommend as first step calling of a representative national economic conference to outline the initial steps.

Worker Security: As steps toward worker security, the following is proposed: Organization of the job market through a system of state employment services under Federal coordination; wage-earners organized into unions of their own choosing and under their own control; distribution of man-hours so that all may have an opportunity to earn a living—when workers have been added to the producing staff, none should be laid off until the hours for all have been reduced at least to 30 per week; higher wages—consumer buying power should expand proportionately to increases in production and services available to raise standards of living; vocational counsel and retraining; larger aspects of unemployment prevention through national economic planning.

Unemployment Relief: Advance planning of public works; use of national credit for self-liquidating projects, for building homes for workers and other small income groups, for slum reclamation, etc.

Unemployment Insurance: It would be desirable, were it possible, to press for the enactment of one uniform measure for unemployment insurance applicable throughout the United States. Since this is practically impossible due to existing provisions, limitations, and regulations, the Federation advocates the passage of unemployment-insurance legislation in each state, and the supplementing of such state legislation by Federal enactments. Underlying objective of insurance legislation: (*a*) Stimulation of more regular employment, and (*b*) payment of unemployment compensation to those who are temporarily out of work.

Status of Plan. Approved by the Fifty-Second Annual Convention of the American Federation of Labor.

PLAN OF VERNE LEROY HAVENS

Classification. Payment of international debts.

Author and Origin. Verne Leroy Havens, Consulting Engineer, New York, N. Y.

Objective. Reduce demand (and apparent high price) for gold by utilizing all available means to facilitate direct or triangular payments to us of all foreign debts in media other than gold, although referred to gold as a price standard; dampening gold shipments; reducing raids on our gold supply; blocking fall of real low prices of goods and services; reestablishing credit margins and resuming normal trade relations.

Theory or Principle. Gold is wealth only as it is useful in the arts. Its capital utility is as a price standard. Its primary function is as a reserve to maintain par value of currencies, lessen gaps between domestic and world prices, and to meet international balance of payments. Debts cannot be paid in gold. They can be paid only by men at work. The proof of maladministration of debts is that when the world is most anxious to liquidate national and commercial obligations some sixty million men are relieved from employment.

Methods Advocated. The first essentials are: (1) Commercialize intergovernment debts; (2) forget gold as a medium of settlements while maintaining it as a standard of prices; (3) set up a commercial settlements corporation functioning as a clearing house through the medium of bank credits; (4) establish contact with central authorities of thirty-three (or more) different countries where no commodity, negotiable document, person, service, or thing crosses the frontier without special consent of authorities.

Author's Evaluation. This is a basic problem, simple in principle, structure, and solution with small capital. It is a big job, but not so big as to frighten us.

PLAN OF FREDERICK W. KELLEY

Classification. Regulation of competition.

Author and Origin. Frederick W. Kelley, late President, North American Cement Corporation, Albany, New York.

Objective. Maintenance of minimum prices at cost.

Theory or Principle. "Problem is to preserve the advantageous features of competition but to adapt it to modern conditions of mutual, social, and economic interdependence." "Competition must be made constructive, not destructive."

Method Advocated. Each industry to have a trade association vested with a large responsibility for sound practices and conditions within the industry.

"Unfair competition" to be eliminated by declaring the *initiation* of prices in an industry "at less than cost" to be unfair, together with the enforcement of corrective measures through suitable policing.

Deny the right to any one to lower his *initiated* price below that of a competitor; he may meet the price, but not beat it. A lowered price may be *initiated* if warranted by lowering cost.

Author's Evaluation. Would give the most efficient members of an industry a fair and reasonable profit.

Under this plan there would be no necessity for control of entrance to an industry.

Status of Plan. Proposal only.

Supporting Comment. The intended suppression or minimizing of cut-throat competition will contribute in large degree to the stabilizing of industry with its resultant ironing out of the valleys and peaks. The fixing of minimum prices at cost will tend to discourage the unwarranted entry of newcomers in overbuilt industries.

Objecting Comment. The fixing of costs offers problems difficult to solve, such as the fair valuation of properties; the treatment of varying circumstances in different localities as affecting rates of return on capital, salaries, bonuses, wages, working

conditions, etc.; and the fair allocation of overhead costs among a multiplicity of products in a given industry.

The stabilizing of prices holds forth the danger of promoting monopoly and of discouraging lessened costs to consumers.

PLAN OF F. J. KUNNECKE

Classification. Business and financial stability and a way out of depression.

Author and Origin. Prof. F. J. Kunnecke, University of Dayton, Dayton, Ohio.

Objective. To pull us out of depression, prevent future depressions; to stabilize business, finance, agriculture, and labor.

Theory or Principle. Depressions primarily caused by purchasing power reduction due to excessive use of profits for extension of productive properties; by so speeding up production men early become incapacitated, thus compelling industry, through charity, to carry large numbers without purchasing power; the speed of machinery should be divided among labor, but with full wages to all.

The farmers have suffered from too many middle men, too much speculation on farm products, insufficient credit, lack of purchasing power among the industrial class, and a deficiency in knowledge as to demand for their product, resulting in overproduction.

Methods Advocated. For industry: (1) Dividends declared out of profits to labor and capital to maintain balance between production power and consumption buying power; (2) reduction in speed in industrial operations to capacity of men of 50 years of age to extend earning time, or share work with full wages.

For agriculture: Regulate the number of middle men; prohibit speculation in farm products; extend longer credit; furnish accurate information for demand for farm products.

For finance: Regulation of interest in any form; governmental control of the credit element of our monetary system; establishment of an honest dollar through the principle of multiple tender.

For the immediate depression: Confer large emergency powers upon the President, who shall direct operations through the Federal Reserve Board and the Federal Trade Board; boards to be reconstituted to include economists and business representatives; their decisions to be supported by prompt action of the Department of Justice. Author would institute many reforms, such as stop all issue by banks and other financial institutions of present currency, and replace this same by short-time currency issued to financial institutions, secured by deposits of actual currency; close stock exchanges temporarily; prohibit temporarily foreclosures and liquidation, because this tends to concentration of wealth.

As concerns business during the emergency: Enforced agreement among producers of similar product to apportion types of product among themselves; salaries of officers at lower scale than prevailing; limit further investment and replacement of equipment; order the wheels of industry to move, and force banks, by taxation upon unnecessarily retained currency, to loan capital for the operation of industry.

Author's Evaluation. Application of plan would lead the nation out of this depression and ward off future repetition.

PLAN OF JOHN S. LENNOX

Classification. Maintenance of purchasing power by monetary means.

Author and Origin. John S. Lennox, Engineer, General Electric Company, Pittsfield, Mass., in book, "The Cause and Cure of Unemployment."

Objective. To maintain purchasing power for the full output of the productive mechanism for such a period of hours as men wish to devote to work.

Theory or Principle. Under the gold standard, when credit is being expanded (that is, when debts are increasing), spending and income increase in a self-generating cycle. When the time comes that credit expansion ceases (that is, that debts are paid up as fast as or faster than they are incurred), there is initiated a self-generating cycle of diminishing expenditure and income.

Method Advocated. A new monetary system, the "Public Works Standard," under which 100 per cent employment would be assured by always maintaining a surplus of tenders for public works to be paid for with new money which would be retired (amortized) out of taxes as the works depreciated.

Positive Federal control of the commodity price index is provided with local planning of public improvements.

Author's Evaluation. Necessity for large debt structure eliminated; national income stabilized; current debts paid out of earnings; international debts paid in goods; commodity price level permanently stabilized without price fixing; absolutely individualistic; can be started instantly by any one nation and become effective in a few months.

Status of Plan. Proposal only.

PLAN OF EMANUEL LISSNER

Classification. Industrial stabilization.

Author and Origin. Emanuel Lissner, Engineer, San Pedro, Calif. Published in January and February, 1933, issues of the *American Engineer.*

Objective. "My preventive will not perpetuate such feverish boom times as we had at the start of the year 1929, when we were on the brink of a precipice without knowing it. It will render impossible such periods of over-expansion, just as it will the periods of depression. It is designed to flatten the peaks of the charted line of business activity as well as to level the hollows."

Theory or Principle. The outstanding cause of the present depression has been the over-expansion of our productive facilities, not only in manufacturing, but also in agriculture, mining, transportation, merchandising, communications, real estate, entertainment, and other similar lines. Until very lately the quality of thrift has been accorded undiluted praise, but today it comes in for a share of criticism. The old idea has been that thrift, by providing funds for investment, creates additional employment; the new one is that it actually cuts down employment by limiting consumption. The truth lies somewhere between these two theories.

Method Advocated. For every industry an association under a dictator who would have two main duties: (1) Prohibit unnecessary expansion; (2) when expansion was warranted, allocate it among members of the association. He would also fix selling prices, diversion of markets, and make decisions about dividends, wages, and working hours.

Author's Evaluation. Money now lost in over-expansion will be used for consumers' commodities. Corporations will reduce their surpluses by distributions among officials, stockholders, and employees. A portion will be placed in pension and unemployment funds. To be a success, trade associations must provide practically continuous employment for all wage earners. This probably involves a reduction in working hours.

Status of Plan. Proposal only.

PLAN OF NORMAN LOMBARD

Classification. Business and economic stabilization through money and credit control.

Author and Origin. Norman Lombard, former Executive Vice-President of The Stable Money Association, New York, N. Y.

Objective. Promote condition which will yield maximum increment of goods and services and distribute them equitably in proportion to the value of contribution made.

Theory and Principle. Condition best approximated when general level of prices is kept stable. Production, wages, and employment increase at competitive rates. Living standard rises as reflected in more goods and leisure. Fluctuating prices reduce production, promote waste, and redistribute wealth without plan or purpose.

When general price level rises: Creditors are injured; equities between debtors and creditors are disturbed to advantage of former; undue business activity encourages uneconomic expansion; extravagance, boom conditions, inefficiency.

When general price level falls: Debtors are injured; creditors profit; reduced consumption and employment result; wage and debt readjustments promote social and political unrest.

The general level of prices reflects value or purchasing power of money. When it rises, money falls in purchasing power. When it falls, money rises in purchasing power. Money is subject to the law of supply and demand.

Total volume of credit, money, and money-like instruments should be kept in effective circulation in such balance with the varying needs of business that the general level of prices will be kept stable, letting changes in such volume compensate for variations of velocity, hoarding, banking fears, and other factors of the equation.

To do this it may be necessary for monetary authorities to anticipate impending changes in the price level and to take steps to offset them before they become apparent statistically. Their power should be plenary and responsibility complete.

Methods Advocated. Stabilization of internal price level disregarding fluctuations of exchange or gold reserve ratios, cooperation with foreign countries in stabilizing exchange as a secondary objective.

Machinery of control of money and credit exists in the Federal Reserve through its power: (1) To raise or lower the rate of rediscount; (2) to buy or sell (*a*) eligible securities and (*b*) foreign exchange in the open market; (3) influence banking policy through direct contact; (4) mold public and business opinion through announcements of its policy and of its reasons for taking action.

In the present emergency, further expansion of member-bank loans and investments should be forced by increasing surplus reserves. Therefore the Federal Reserve should discontinue selling securities to keep reserves at a "reasonable level" and allow incoming gold and money returning from hoarding to have its natural expansive effect, thus tending to cause lending by member banks, thus increasing effective credit volume.

The problem is political and technical rather than economic. In the public interest, and to protect banks from their own folly, there should be an international, non-political, non-governmental organization, devoted to furthering the stabilization of the price level.

Author's Evaluation. Eternal vigilance is the price of stability. Price-level stabilization is more necessary than any other social or governmental reform.

Status of Plan. As relates to the organization of public sentiment: The situation is chaotic, the advocates of price level stabilization, numerous and influential as they are, being without leadership or financial support.

As to cooperation between governments and central banks: In England and some other countries it is complete; in America it is completely lacking.

As to central banking controls: This philosophy recommended by conference of thirty nations in 1922. The period of stability in America from 1922 to 1928 was due to the more or less deliberate application of these principles.

PLAN OF LEWIS L. LORWIN

Classification. Industrial stability and economic advance.

Author and Origin. Dr. Lewis L. Lorwin, Member of the Council of the Brookings Institution, Washington, D. C.

Objective. Adjustment of a progressively growing productive mechanism with a progressively rising standard of living.

Theory or Principle. Social progressive planning as distinguished from other types; namely, state socialist, nationalistic, and business planning.

Definition: A planned economy is a scheme of economic organization in which individual and separate plants, enterprises, and industries are treated as coordinated units of a single system for the purpose of utilizing all available resources to achieve the maximum satisfaction of the people's needs within a given time.

Essential features: (1) Interdependence of all production units; (2) adjustment of a progressively growing productive mechanism with a progressively rising standard of living; (3) existence of some unifying center to direct the system consciously toward these nationally recognized ends; (4) planning is a synthesis of the ideas of dynamics and order, of science and imagination. It is a new mode of feeling life and of living.

Method Advocated. Social progressive planning implies redistribution of income (through an annual wage, five-day week, six-hour day, utilization of leisure), an extension of the demand side of economic life, a variation of the range of return in relation to social service, and methods for directing the flow of capital.

This type of planning, while rejecting dictatorial methods, demands some control through a central unifying agency—a National Economic Council—which is expected to bring into life boards and commissions which, working together with the Federal Reserve Board, the Farm Board, the Interstate Commerce Commission, etc., could guide the course of our national economy. Management, labor, technicians, and scientists should come together to supply both the planning and the administrative machinery for carrying out plans. Planning must have a national character and a measure of governmental authority.

The author presented to the Amsterdam Congress on Social Economic World Planning (I.R.I., Aug., 1931) what might be called a Five-Year World Plan, based on the following: (1) A general five-year moratorium on all war debts and reparations payments, with a presumption in favor of final cancellation if the effects of the moratorium warranted it. (2) A series of international loans carried through the cooperation of the chief lending countries and revised in such a way as to promote productive resources in the most promising areas and increase world purchasing power. (This might be done through a World Industrial Bank.) This would also offer an opportunity to affect and modify commercial policies through agreements by which credit would be extended on condition that a tariff truce be observed or that tariff schedules specially detrimental to trade be modified. (3) A series of international agreements for the division and control of the world market by producers of raw materials and of some manufactured goods.

PLAN OF FREDERICK H. MCDONALD

Classification. A plan to stabilize the business structure through individual corporate "stabilization reserve funds."

Author and Origin. Frederick H. McDonald, Consulting Engineer, Atlanta, Ga.

Objective. To equalize the business curve by using reserves

accumulated during prosperity to maintain in lean periods a minimum level of operations and income; to maintain and widely distribute purchasing power; to direct over-investment from the production of consumer goods or services toward community facilities or public works at proper periods; and to avoid revolutionary changes by providing acceptable evolution of the present business structure.

Theory or Principle. Author assumes that fluctuations in business activity are inevitable, and plans to mitigate the severity of national variations through the cumulative effect of tempered variations in individual enterprise.

Method Advocated. Legally require profit-making enterprises to establish a segregated reserve fund by withholding distribution of all earnings in excess of legal rate of interest on capital invested until minimum reserve is attained, fund to be trusteed. After completion of minimum reserve, future excess earnings to be distributed on voluntarily agreed basis between labor, management, and owners. In lean periods, reserve fund to be used to maintain minimum levels of wages, salaries, and dividend payments, based on fair rates of average income agreed for considerable periods between owners and employees. Fiscal policies to be based on decades rather than limited annual status. Reserve funds to be invested primarily in obligations of local governmental bodies for public-works construction, through central or Federal investment channels. No state or governmental infringement or regulation of business operation except to insure compliance with law through annual public reports to state.

Author's Evaluation. By these means the bulges and depressions of business can be leveled as they would reduce excess activity, unregulated expansion, excessive or premature disbursement of profits, over-investment in industry, distribute purchasing power during active times, and care for resulting minor unemployment and loss of income in dull periods.

Status of Plan. A series of articles in current issues of *Review of Reviews and World's Work.* In the October issue, 1932, is a discussion of the advantages and disadvantages of the plan.

PLAN OF CHARLES A. ROBERTS

Classification. Governmental taxation and construction policies.

Author and Origin. Charles A. Roberts, Member of New York Bar. Paper reprinted from *Tax Magazine*, December, 1931.

Objective. Preventing industrial expansion which is not supported by purchasing power and also increasing purchasing power.

Theory or Principle. (1) World tends persistently toward overproduction. With cyclical regularity the aggregate of goods and services produced becomes too great for the stream of money to move it. Too much income is devoted to new production, and too little to maintaining the continuous flow of expenditure by consumers.

(2) Income tax puts a wholesome brake on the growth of productive facilities, and furnishes (through governmental expenditures and through increased expenditures by business men for advertising, etc.) a needed accelerator to the public's buying power.

(3) A taxpayer's costs cannot be increased indirectly by reason of the imposition of income taxes on his suppliers.

(4) Income remaining after current expenditures and income taxes is the sum available for reinvestment.

(5) Two variables fluctuate in direct proportion. The "clear income" (the net effective addition which can be made to the invested capital of the community) must vary strictly in accordance with the rate of growth in the buying power of the public.

Methods Advocated. (1) "The personal exemption from income tax should be increased from \$1500–\$3000 to say \$4000–\$8000. This change would eliminate two-thirds of the 4,000,000 individual tax returns."

(2) "The normal tax should be reduced to 1% flat."

(3) "In lieu of exempting dividends from normal tax, every stockholder should be given a credit, against his total tax, equal to 15 per cent of all dividends received by him."

(4) "The corporation income tax rate should be raised."

(5) "A credit against the Federal income tax (and not as at present, a mere deduction from income) should be granted for income taxes paid to the states."

Author's Evaluation. Net effect, the foregoing proposals would likely increase the revenue by some 300 million dollars. In anticipation of such additional revenue plans should be made for its prompt disbursement, ***otherwise than for debt retirement.***

Status of Plan. Proposal only. See O'Connor bill, H.R. 12,643, pending in Congress, January, 1933.

PLAN OF JOHN WILLARD ROBERTS

Classification. To cure unemployment through income taxes distributed as old-age pensions.

Author. John Willard Roberts, New York, N. Y.

Objective. Prevent business cycles through balanced production and consumption.

Theory or Principle. Over-mechanization is the cause of unemployment and over-production, and destroys the values of capital goods through over-supply. This destruction of values can only be avoided by controlling the degree of mechanization. Measures to meet the situation by perfecting currency and credit institutions are futile before the overwhelming forces exerted by over-mechanization. Mechanization arises from investment, which in turn arises from savings. To regulate mechanization we must regulate savings, diverting purchasing power out of the hands of those who invest it so as to run to excess the creation of capital goods, and into the hands of those who will spend it on living. At the same time we must reduce the urgency of the need for savings.

Methods Advocated. Revision of income tax laws to make income tax more effective and productive by proper adjustment between corporation and individual rates.

Author's Evaluation. Would avoid bureaucratic dictation of business details, conserve incentives of effort and initiative which have constructed marvelous productive powers.

Stabilize industry while permitting rapid growth; by preventing over-production, would prevent depressions; if recession appeared, would provide immediate remedy by increasing pensions and taxes.

Would maintain the demand for workers, freeing them from fear and enabling them to claim good wages and working conditions.

Would care for the superannuated.

Would maintain the value of investments, and the independence and self-respect of citizenry, thus conducing to better government.

Would relieve the pressure for making foreign loans and pushing exports into unwilling countries; would not prevent a large foreign trade, but would make it a less desperate competition, and thereby improve international relations to a marked degree.

Although its effectiveness would reach its greatest development by world-wide application, it does not need to wait for unanimous adoption by many nations. If one nation, such as the United States, should adopt it, the others, seeing its beneficent effects, would soon follow suit.

PLAN OF M. C. RORTY

Classification. Stimulation of business activity.

Author and Origin. M. C. Rorty, formerly Vice-President, International Telephone and Telegraph Corporation, New York, N. Y.

Objective. Immediate relief of unemployment, with ultimate development to control business fluctuations.

Theory or Principle. Supplementing of other measures for economic stabilization by increased stabilization of construction, reconstruction, and other new capital operations. Special stimulation of reconstruction, reequipment, and other capital activities in times of extreme depression, through use of a relatively small volume of public funds to induce much greater expenditure of private funds.

Methods Advocated. Payment of direct premiums out of Federal funds to encourage private initiative in construction, reconstruction, and other capital operations.

Advertise for bids for the initiation of the new activities. Such bids shall be in terms of the required percentages to be paid as premiums upon certified and audited amounts disbursed for wages and materials, the awards of premiums to be made in the order of the lowness of such bids, after allowing for certain preferentials to reconstruction and other preferred operations. Self-supporting state and municipal works to be eligible for premiums.

Initial funds to be furnished by advances from Federal Government, to be repaid from proceeds of special taxes assessed for the purpose.

Author's Evaluation. "The real cost of even a moderate business depression is, perhaps, not less than 10 billions of dollars...cost of present depression will very probably exceed 50 billions of dollars....the maximum cost of stabilization, per business cycle, in excess construction and new capital investments, should very certainly be less than 2 billions of dollars."

Status of Plan. Presented to Institute of Public Affairs, University of Virginia. Printed as supplement to April, 1932, issue of *Harvard Business Review*. Has been presented to Federal Administration. May be proposed in modified form to next Congress, primarily as a measure of immediate unemployment relief.

Supporting Comments of Author. "....majority of students of the business cycle are prepared to admit that the plan...has the power to produce results and that it probably could be made effective in the hands of an intelligent economic czar."

Objecting Comments of Author. Even under present conditions, some premiums might be paid for operations that would be started without such payments and some work delayed in expectation of premiums. Initial operations would have to be restricted mainly to reconstruction and rehabilitation projects, and non-competitive construction. Plan would require ample administrative authority, and ultimate applications for general economic stabilization should await results of experience as emergency measure.

PLAN OF CHARLES R. STEVENSON

Classification. Business and manufacturing stabilization.

Author and Origin. Charles R. Stevenson, of Stevenson, Jordan, and Harrison, Management Engineers, New York, N. Y.

Objective. To secure balanced production and consumption.

Theory or Principle. Balance production and consumption by reducing competition through rearrangement of industry (mutual trade agreements); limit freedom of individual to engage in industry as he sees fit; hours of labor are matters for national and not state legislation.

Method Advocated. (1) Modification of anti-trust laws; (2) grant the right of any industry, if 85 per cent of capital invested desires, to organize in a definite way; (3) create a commission to regulate such organized groups of industries; (4) give Congress power to regulate hours and wages; (5) set up a labor commission to regulate and enforce items under (4).

Author's Evaluation. These adjustments would provide work and adequate earning power for every one who wished to work; would provide security of employment, increased earning power for the worker, and security of capital and return for the investor in industrial securities.

Status of Plan. Proposal only.

PLAN OF GERARD SWOPE

Classification. Industrial stabilization.

Author and Origin. Gerard Swope, President, General Electric Company. Based on experience with unemployment allowance plan in effect in his company for some two years.

Objective. "...industry must evolve and make effective those measures which will first ameliorate (unemployment) and ultimately eliminate it....."

Theory or Principle. (1) Every effort should be made to stabilize industry and thereby stabilize employment to give to the worker regularity and continuity of employment, and when this is impracticable, unemployment insurance should be provided.

(2) Organized industry should take the lead, recognizing its responsibility to its employees, to the public, and to its stockholders; rather than that democratic society should act through its government. If the various states act, industry will be confronted with different solutions, lacking uniformity and imposing varying burdens, making competition on a national scale difficult. If either the individual states or the Federal Government act, the power of taxation has no economic restraints.

(3) There should be standardized forms of reports so that stockholders may be properly informed.

(4) Production and consumption should be coordinated on a broader and more intelligent basis, thus tending to regularize employment and thereby removing fear from the minds of the workers as to continuity of employment, as to their surviving dependents in case of death, and as to old age.

(5) If organized industry is to undertake this work, every effort should be made to preserve the benefits of individual originality, initiative, and enterprise, and to see that the public is assured that its interests will be protected; this can be done most effectively by working through the agency of the Federal Government.

Methods Advocated. (1) All industrial and commercial companies (including subsidiaries) with 50 or more employees, and doing an interstate business, may form a trade association which shall be under the supervision of a Federal body referred to later.

(2) These trade associations may outline trade practices, business ethics, methods of standard accounting and cost practice, standard forms of balance sheet and earnings statement, etc., and may collect and distribute information on volume of business transacted, inventories of merchandise on hand, simplification and standardization of products, stabilization of prices, and all matters which may arise from time to time relating to the growth and development of industry and commerce in order to promote stabilization of employment and give the best service to the public. Much of this sort of exchange of information and data is already being carried on by trade associations now in existence. A great deal more valuable work of this character is possible.

(3) The public interest shall be protected by the supervision of companies and trade associations by the Federal Trade Commission, or by a bureau of the Department of Commerce, or by some Federal supervisory body specially constituted for that purpose.

(4) All companies within the scope of this plan shall be required to adopt standard accounting and cost systems and standardized forms of balance sheet and earnings statement. These systems and forms may differ for the different industries, but will follow a uniform plan for each industry as adopted by the trade association and approved by the Federal supervisory body.

(5) All companies with participants or stockholders numbering 25 or more, and living in more than one state, shall send to its participants or stockholders and to the supervisory body at least once each quarter a statement of their business and earnings in the prescribed form. At least once each year they shall send to the participants or stockholders and to the supervisory body a complete balance sheet and earnings statement in the prescribed form.

(6) The Federal supervisory body shall cooperate with the Internal Revenue Department and the trade associations in developing for each industry standardized forms of balance sheet and income statement, depending upon the character of the business, for the purpose of reconciling methods of reporting assets and income with the basis of values and income calculated for Federal-tax purpose.

(7) All of the companies of the character described herein may immediately adopt the provisions of this plan, but shall be required to do so within three years, unless the time is extended by the Federal supervisory body. Similar companies formed after the plan becomes effective may come in at once, but shall be required to come in before the expiration of three years from the date of their organization, unless the time is extended by the Federal supervisory body.

(8) For the protection of employees, the following plans shall be adopted by all of these companies: A workman's compensation act; life and disability insurance; pension; and unemployment insurance.

Author's Evaluation. "By this method American industry can discharge its obligation to its employees and, by holding its position in the markets of the world, bring additional work to America."

Status of the Plan. Presented to the National Electrical Manufacturers Association, September 16, 1931. The Board of Governors of the Association passed resolutions commending Mr. Swope for preparing a completely formulated plan; expressing the belief that a plan of stabilization of industry would be of aid to all concerned; recommending that the Policies Division of N.E.M.A. through a special committee make a careful study and develop, in cooperation with trade associations, a constructive program contemplating stabilization of industry with adequate protection for all of the elements involved.

PLAN OF U. S. CHAMBER OF COMMERCE

Classification. Suggestions for stabilizing industry through voluntary action of business men.

Author and Origin. A report of the Committee on Continuity of Business and Employment, of U. S. Chamber of Commerce, Henry I. Harriman, of Boston, Chairman. Printed copies distributed to constituent members and made publicly available, Oct. 30, 1931.

Objective. To secure better balance between production and distribution.

Theory or Principle. Advocates limited amendment of anti-trust laws; the setting up of a National Economic Council; the voluntary adoption by employers of unemployment reserve plans; the voluntary development of uniform plans for protection against unemployment, old age, sickness, and accidents by trade associations. These and other topics are presented under three headings: (1) Causes of depression and unemployment; (2) long-time measures for lessening effect of depression; (3) means for meeting immediate unemployment conditions.

Cites as causes of the depression, wars, undue expansion, and speculation. Does not believe that technological advance is the main cause of the depression, but admits there is a problem to be solved. Expresses belief that gradual shortening of hours of labor should continue in the future.

Methods Advocated. Advocates modification of anti-trust laws to legalize voluntary agreements designed to keep production related to consumption, such agreements to be under supervision of a governmental agency. Advocates industrial planning by representative trade associations and national planning through a national economic council. Proposes a National Economic Council of three to five members of highest standing and representative of the country as a whole, privately organized and sufficiently financed so that it could employ highest grade of economists, etc.

Status of Plan. Acceptance by general referendum of Chamber.

PLAN OF ERNEST J. WOLFE

Classification. Unemployment relief.

Author and Origin. Ernest J. Wolfe, Instructor in Economics, Columbia University. Plan "has been developed through an exchange of communications with students, professors of economics, and state and Federal Government officials."

Objective. To alleviate unemployment.

Theory or Principle. "A conservative principle underlying this plan is that we should prepare in periods of prosperity for periods of depression." Financing of plan is to be jointly by workers and the Government.

Methods Advocated. "It is proposed that units be established for the production and distribution of commodities, and provision made for the rendering of services adequate to maintain a comfort level of living." Among the commodities that are to be produced are: The various economical cuts of beef, veal, mutton, lamb, and pork, fresh fish, salt fish, chickens, eggs, lard, butter, milk, wheat flour, cornmeal, potatoes, cheese, vinegar, molasses, dry beans, prunes, evaporated apples, and rice, the commonly used items of men's, women's, and children's clothing, various forms of fuel, furniture, tobacco, and the commonly used building materials.

"Each unit, or the several units in a community, shall be organized as a corporation. A holding corporation is also to be organized, which is to hold the stock of all the productive and distributive units.

"The United States Government is to own all the stock of the holding corporation, and is to hold this stock in trust for the workers of the United States."

There are to be two types of workers, "those who constitute the permanent staff, and those who are employed only until there are positions available to them in private industry."

"......output shall be restricted to amounts required by the personnel both during normal and emergency times." Workers not needed for this production "shall be employed in public projects."

"In the first year of the operation of this plan, and until such time as an adequate reserve has been accumulated, a graduated tax of 1 to 5 per cent shall be levied on all incomes in excess

of $1200 derived from wages and salaries of all workers in the United States."

Author's Evaluation. "......the plan is thoroughgoing." "It is clearly realized that this proposal is not an attempt to solve all our economic problems."

Status of Plan. Proposal only.

CLOSURE

The preceding list of causes or possible causes of economic dislocations and business instability (Part I), and the assay of plans, programs, and remedies (Part II), are representative of the thinking of the past year. To the extent that the causes are recognized as valid and the remedies as feasible, the presentation is, on the one hand, impressive, and on the other discouraging. These points of view are distinctly those emphasized by the material as a whole which has reached the Committee in the study which has yielded this report.

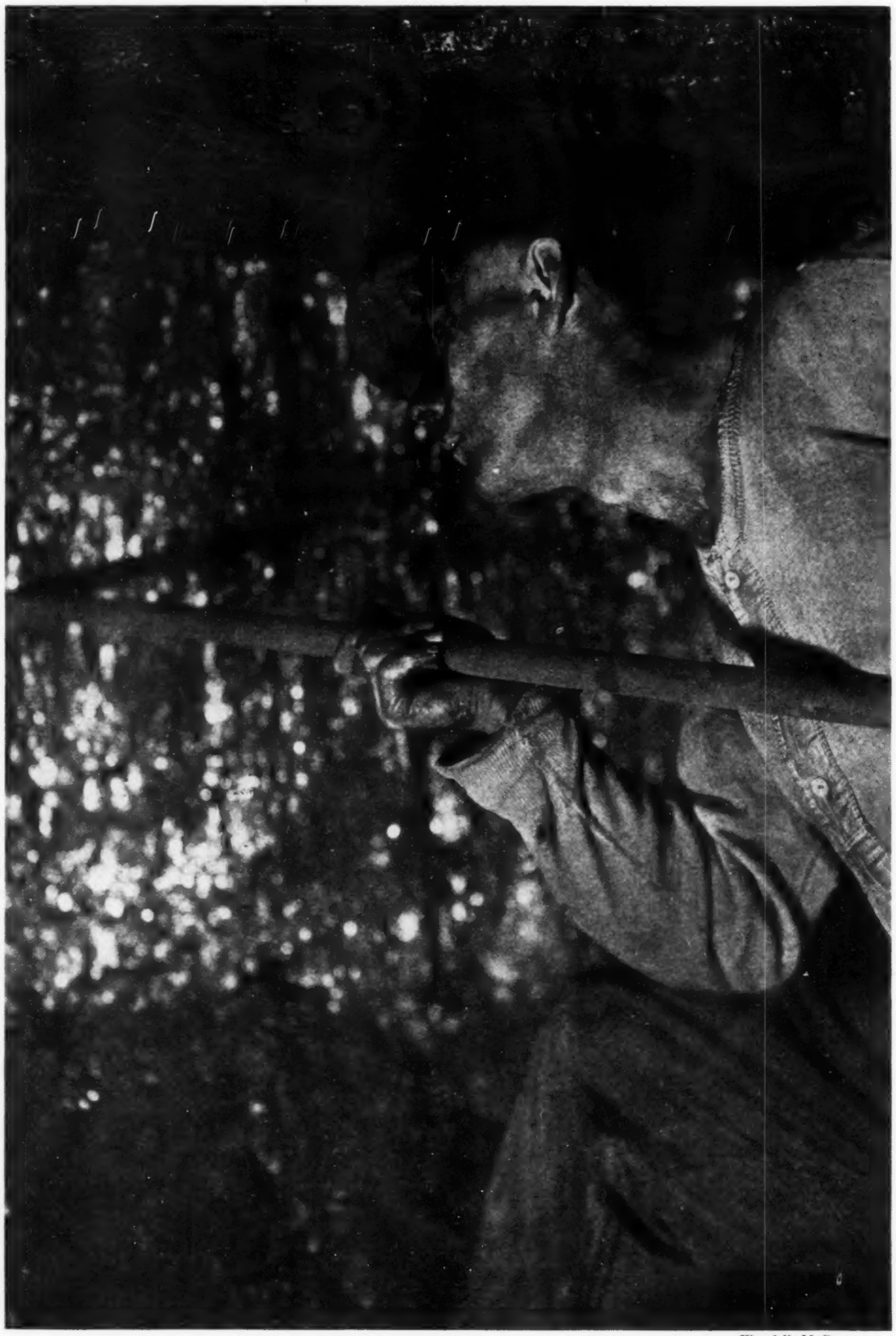
The single finding which the Committee is willing to support at this time, drawn from the presentation of causes and remedies, is that no one all-inclusive cause can be designated as the forerunner of business recession, nor can any one all-inclusive remedy be found as a preventive or cure.

The situation that this finding presents should occasion neither surprise nor discouragement. Emphasis is merely given to the accepted fact of the complexity of our business and industrial structure, and to the interaction of economic forces.

The problem of social and economic control is of such magnitude that its solution will be a major event in the history of civilization. The project cannot, and must not, be approached from any inferior estimate of difficulty or extent.

This second progress report should be considered as superseding its predecessor of a year ago for the reason that it indicates the direction and quality of thinking of a year of intense business stress. The next effort of the Committee may well be to select and present those elements of remedial programs which seem feasible and practicable, and which promise to integrate into a program of social and economic control. This integration will only be attained through a slow evolutionary process.

R. E. FLANDERS, *Chairman*
L. P. ALFORD
F. J. CHESTERMAN
DEXTER S. KIMBALL
F. H. McDONALD
L. W. WALLACE
W. J. WILGUS.

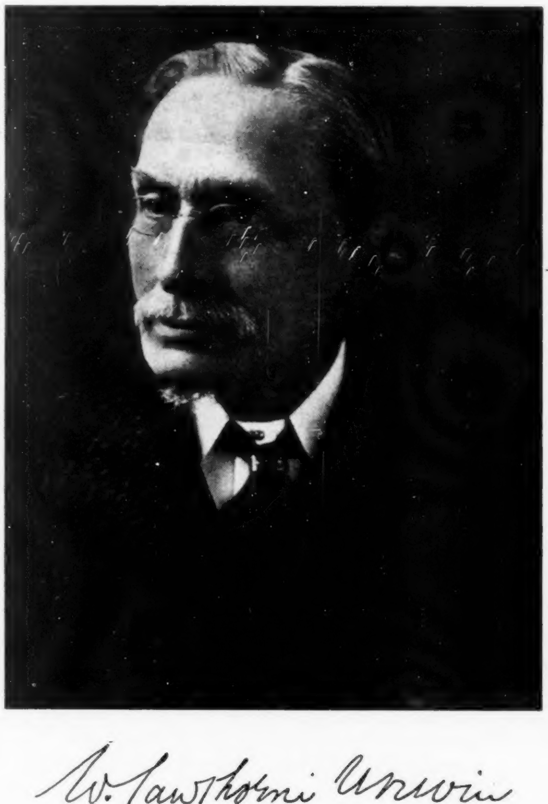


Wendell McRae

WILLIAM CAWTHORNE UNWIN, 1838-1933

IN 1890, when the Cataract Construction Company began laying plans for the large-scale development of power at Niagara Falls, the problem of the engineering features involved was referred to an international commission consisting of Sir William Thomson (Lord Kelvin), president, Dr. Coleman Sellers, Prof. E. Mascart, of Paris, France, Col. Theodore Turrettini, of Geneva, Switzerland, and Prof. William Cawthorne Unwin, secretary.

The modern age to which the younger engineers now practicing belong finds it hard to understand the uncertainties that faced this commission. For the generation of electricity in large amounts by hydraulic turbines, the transmission of the current generated over long distances, its distribution and use in mechanical and chemical industries, and hundreds of technical problems such as the relative advantages of alternating and direct current were being attacked in pioneer fashion. Nor was it certain that the development should be an electrical one. Electricity was new; it had never been generated centrally in large quantities for distribution over long distances to points where it could be used. While lighting by electricity had been broadly introduced, industrial power was still largely by mechanical means. The Evershed project, upon which the Niagara scheme was based, was entirely hydraulic and contemplated a community of industries deriving their power from individual hydraulic turbines fed from a common canal—the use of power at the site. Mechanical (telodynamic) and pneumatic transmission systems were in a position to contend for consideration with hydraulic, steam, and gas methods of transmission and distribution. Moreover, the machinery and auxiliary apparatus, as well as the construction of the hydraulic details, were of a scale heretofore untried, so that the stakes, engineering as well as financial, were high and hazardous. Professor Unwin's book, "On the Development and Transmission of Power From Central Stations," comprising the Howard lectures delivered before the Society of Arts in 1893, contains his reflections on the methods in use and proposed at that time, and is indicative of the state of the art when the Niagara development was under consideration.



Professor Unwin, as secretary of the international commission conducting, on behalf of the Cataract Construction Company, the contest for the best solution of the Niagara problem, received the great variety of plans and proposals that were offered and, in 1893, wrote the report in which they were analyzed and appraised. It was this service that brought him into most intimate relationship with engineering on this continent and won for him, in 1898, honorary membership in The American Society of Mechanical Engineers.

Writing 25 years later of the work of the Commission, Professor Unwin said: "The projects were of extremely varied character. Hydraulic turbines of impulse and reaction types of from 2000 to 10,000 horsepower; distribution by electricity, by compressed air, and by wire ropes. Most of the electrical schemes proposed direct-current production and distribution with varying current and constant voltage. Messrs. Siemens proposed constant direct current at varying voltage; Professor Forbes only proposed alternating current. From the first, electrical distribution of the power was in favor, but was not definitely decided upon until May, 1893." Of the significance of the project itself he wrote: "Civilization may be measured by the degree in which human labor is replaced by power derived from natural sources of energy. . . . At Niagara some 7,000,000 horsepower which might have been available for industrial purposes was being wasted. The conditions were favorable for utilization in other respects for the fall was a high one and the Great Lakes from which the water flows act as reservoirs equalizing the supply. The installation has been carried out with complete success, and it is the first large-scale undertaking of the kind. It has been the parent of many others in different parts of the world, or at any rate showed the way to others to achieve a similar success. But the risk of misadventure in so novel and complicated an enterprise in the days when it was carried out was great, and that no serious mistake of judgment or calculation occurred witnesses to the remarkable care with which the preliminary investigations and discussions were conducted."

The Niagara decisions were momentous ones and have had their effect on the industrial and engineering development not only of the district immediately surrounding Niagara Falls and the city of Buffalo, but of the rest of the country and the world at large. For success at Niagara led the way to future developments, and gave a decisive answer to the major policies affecting the generation, transmission, and distribution of hydro power for years to come. It made feasible the development of sources of hydro power that are remotely located with respect to centers of population and ultimate use. It raised social, economic, and political problems in controversies over which this country in particular is still enmeshed. While

(Continued on page 336)

MECHANICAL ENGINEERING

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GEORGE A. STETSON, *Editor*

New Blood

AN obscure notice at the end of this issue records the fact that 980 student members of The American Society of Mechanical Engineers are making application for Junior membership in this society. In times when 980 is a lot of anything, except unemployed, this figure is impressive and arouses a variety of emotions. The sardonic, the discouraged, the pessimistic, the holders of lost illusions are likely to give cold comfort to these young men. But life has an irresistible forward flow and extraordinary powers of recuperation. What it may lack today in the way of security and luxury it makes up for in opportunity and vital interest.

It is a great time in which to be alive, so close to the fundamentals of life that values are easily appraised, and these young men face a brighter future because of it. Their concern will probably be more consciously directed to the complete fabric of human affairs than was that of their predecessors who pioneered in isolated communities and technologies. The task before them will demand a broader sympathy with social and human values. Times like the present breed a sensitiveness to these things. An optimist will envy the 980 their opportunities.

Help From Science

WHILE the microscope is an invaluable instrument in the hands of a skilled observer, it is not used to look below the surface. Hence microscopic examinations of metals are not employed in the study of subsurface structure except in so far as the interior can be guessed at by what appears on the surface. The X-ray, on the other hand, will, in many cases, reveal peculiarities of the interior, such as cracks, cavities, and foreign inclusions, that are betrayed by no evidence on the surface. Thus as every new means of investigation is placed at the disposal of scientific investigators, knowledge and understanding increase accordingly. The more of these means there are developed, the faster and surer knowledge advances.

In a brief paper to be found elsewhere in this issue, Dr. Francis Bitter, of the Westinghouse Research Laboratories, describes a method of investigating the structure of metals that will be new to a majority of mechanical engineers. Readers of Dr. Bitter's paper will be convinced that great possibilities in the way of a more thorough understanding of the structure of metals are inherent in this method, which places another tool in the hands of the investigator.

Scientific investigations of the structure of metals have yielded a rich harvest for engineers in the development of new materials and their proper selection and treatment in engineering design and construction. Engineers want to know more about the use of the magnetic powders described by Dr. Bitter and the results that are derived from investigations by this means. They urge their scientific brethren to continue their studies of the structure of metals as completely and as rapidly as possible. Engineers will make use of scientific knowledge just as quickly as it is available for practical application.

Perfect the Rules

ONE of the engaging qualities of those who offer plans and programs designed to lead helpless mortals into utopias of sweetness and light is their confidence in the efficacy of their proposals. Now it is not to be doubted that, given a unanimity of purpose and properly coordinated action, most of the schemes proposed by intelligent men after mature study would meet with a fair measure of success. What would militate most powerfully against them, however, would be the lack of these very factors in a nation having such a diversity of desires, objectives, opinions, education, faith, and natural abilities as is to be found in the United States. Without an omnipotent dictatorship to enforce it, any one of these plans or programs would probably have little chance of success.

Recognizing that this lack of uniformity is so serious an obstacle, education is looked to as providing, eventually, a race of men who will know how to govern themselves in such a way as to avoid the calamities that have overtaken previous civilizations and political systems. And, indeed, little hope is to be cherished if education fails, for then it will be evident that human intelligence cannot become a substitute for laissez-faire.

Despair, therefore, threatens when one contemplates the twenty-three plans and programs that the American Engineering Council's Committee on Economic Balance has analyzed in the section of its report published in this issue of MECHANICAL ENGINEERING, and the conclusion to which the Committee comes that no single remedy for our economic ills has been found. What hope is there for a common agreement among the mass of citizens of our country if such widely different plans and programs are the considered recommendations of intelligent men who have, presumably, given much thought and study to the problem? One yearns for an authority to which to turn in blind confidence; and to such authorities the controlling minorities of certain nations have already turned.

The flux of human affairs provides too uncertain a current in which to trust the destiny of the economic ship with the fixed rudder of a predetermined and rigid plan. By the time such a craft is in mid-stream, it is rushed by the caprice and vehemence of the current against the rocks or into the shoals and backwaters.

Confronted with this melancholy picture, the optimistic chairman of the committee switched the simile to the field of sport. It is the rules of the game, he pointed out, that have been changed to improve football from both the players' and the observers' points of view. The kaleidoscopic shifting of fortunes, the exhilaration, the chance to win remain, but fewer players are borne off the field, and the game is less likely to end in an undisciplined battle in which both players and spectators forget that they have come out for a football match.

A third report is being prepared by the American Engineering Council's Committee. In it, it is hoped, some recommendations as to the rules of the game will be set forth. For undoubtedly we can do more with the rules than with far-reaching and imperfect plans.

Triumph and Disaster

IN adjacent columns of the newspapers of April 4 were reported two events of sensational interest to the entire world, the successful flight of an airplane over Mt. Everest, and the calamitous loss of the U. S. Navy's airship, the *Akron*. One event marked the culmination of long and carefully laid plans, the other a major accident encountered in routine operation. While both have that highly dramatic quality that arrests the attention of all civilized persons, neither can be viewed entirely without respect to its antecedents. A different ordering of the hundreds of details surrounding either of these events, and different reports, or no reports at all, would have reached the public. As it happened, triumph and disaster appeared suddenly side by side, the one strengthening and the other weakening men's faith in their machines.

But even a fatalist can see more than good luck and bad in these two incidents. The history of aeronautics is dotted with spectacular evidences of triumph and disaster, with the disasters made more dramatic by the increasing number of triumphs, and providing, as do the triumphs, the basis for future advances in the art of flying and the construction and operation of aircraft. The heavy toll of the lives of brave and competent men, coming as it does with dramatic suddenness, is as much a spur to those who have faith in aeronautics to perfect their knowledge of and control over the powerful and complex forces with which they must contend as it is an argument for those of lesser faith for the abandonment of airships.

In this connection the experiences of German-built airships should be borne in mind. The *Graf Zeppelin* has made a round-the-world flight and several ocean-crossings, meeting with a great variety of weather conditions. And in an article in the February, 1933, issue of *Mechanical Engineering* on the safety of this type of ship it was stated that "not a single one out of the 115 Zeppelin-built airships has been destroyed by a storm in the air and that only two were lost on account of engineering mistakes in earlier times."

It is in the nature of man to learn from experience, whether it be good or evil. While it is too much to hope that the world has seen its last major airship disaster, a full and intelligent study of all of the circumstances that brought about the crash of the *Akron* and of measures to prevent the wrecking of future ships will partially compensate for the appalling loss of life and property. It will, all will hope, bring about a sober facing of all of the problems with which airship designers and operators must contend. It would be unfortunate if, before thorough and impartial investigation of it can be made, this disaster should lead the United States to follow the course of Great Britain and abandon further development. The people of the United States have a right to demand that future steps be taken in the light of all pertinent facts and conditions.

For the Good of the Profession

WHEN the times demand a careful appraisal of interests, activities, and loyalties, it is well to remember that with respect to scientific and engineering societies there is a duality of benefit—that which accrues to the individual in some direct return from his support, and that which is credited to the good of the profession. It is to this second category of benefits that attention is called.

Professional engineering societies partake more generally of the nature of educational institutions than of trade unions. While schools and colleges are of inestimable benefit to those who study in them, they are also of such benefit to society as a whole that no intelligent person would think of dispensing with them. The former are quite generally supported out of the public purse; and even citizens who receive no educational advantages from them directly, or who have no children to receive such advantages, make no protest when a goodly proportion of their taxes is used for educational purposes.

While the case for colleges and universities is not so generally conceded as is that for the secondary schools, opinion in most states is strongly in favor of public support of institutions of higher learning. Professional engineering societies fall into another category, and aside from certain privileges enjoyed by them under the law, public support is not expected. This, however, does not deny the fact that, although they are institutions largely benefiting their own members, they are essentially educational in purpose and perform some of the functions of colleges and hence partake somewhat of their nature. For this reason, they demand support on this ground as well as the more direct one of personal benefit to the individual.

To form a hasty estimate of the value and extent of the functions of engineering societies in advancing the best interests of the profession, and hence of the nation, it is only necessary to imagine that they had never come into being, and to list the activities in which they engage that they have either originated or taken over. The result is convincing proof of the necessity of considering the good of the profession as well as personal advantage in any appraisal of value.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS (See Railroad Engineering: Wind-Tunnel Development of a Proposed External Form for Steam Locomotives)

AIR ENGINEERING

Air-Compressor Test-Bed Equipment

THIS is a general description of what adequate test-bed equipment should be. Particular attention is called to the matter of measuring air flow by the Pitot tube.

Experimental work carried out by the Aeronautical Research Committee in 1925 to determine the influence of the shape of the nose, position of the stem and static holes, etc., will be found in Reports and Memoranda, No. 981 (Ae. 194), published by His Majesty's Stationery Office.

When used to determine a quantity of air, very great care is required, and the usual method is to lead the air to be measured into a pipe or trunk of suitable cross-sectional area, and the velocity is measured by the Pitot tube at a point along its length where steady conditions of flow have been obtained. Danger of inaccurate results when using this method lies in the fact that the velocity is never the same over the whole of the cross-sectional area of the trunk, and a position of average velocity must be found. The following record of a test will show how great this variation can be.

A volume of about 6700 cu ft per min discharged by a turbo-compressor was led away to a wooden trunk 20 ft long, the cross-sectional area being 17 in. by 12 in. The required pressure was maintained by a valve on the delivery of the tube, and perforated metal screens were placed in the trunk so as to eliminate the eddies caused by the control valve. The outlet end of the trunk was divided into 48 divisions, and the Pitot tube was inserted into the flow, and a reading taken when it was in the center of each division. The manometer readings are given in the following table:

2.0	1.9	1.5	1.2	1.0	1.0	1.4	1.5
1.93	1.3	0.8	0.65	0.7	0.9	1.3	1.7
2.0	1.1	0.6	0.55	0.7	0.95	1.5	2.0
2.5	1.3	0.75	0.6	0.75	0.95	1.45	1.5
3.3	1.85	0.65	0.85	0.8	0.95	1.3	2.6
3.4	2.4	1.6	1.1	1.0	1.0	1.7	2.8

The volume of air in cubic feet per minute at atmospheric temperature and pressure is given by the formula

$$V = 951 \frac{T}{P} \sqrt{h \frac{P}{T_1}} \times A$$

where V = cu ft of free air per min at atmospheric temperature and pressure; T = temperature of atmosphere, deg F, absolute; T_1 = temperature of air in trunk, deg F, absolute; P = atmospheric pressure, in. of Hg; h = Pitot-tube reading, in. of water; A = cross-sectional area of trunk, sq ft.

It will be seen that the volume varies as $\sqrt{h}$, and as the figures in the table vary from 3.4 down to 0.55, the risk of error is very great, and the Pitot-tube method should be used when other means are not available, and its true field lies in measuring the outputs of very large fans when the total head is only a few inches of water.

It is stated that a further abstract dealing with the parabolic or rounded-nozzle method, thin-plate and sharp-edged-orifice method, vacuum pumps, and the measurement of power will appear in a future issue of *Mechanical World*. (Sydney Gaymour, Reavell & Co., Ltd., paper presented to the Institution of Engineering Inspection, Dec. 14, 1932, abstracted through *Mechanical World*, vol. 93, no. 2401, pp. 3–5, 1 fig., *de*)

Pescara Auto-Compressor

IN THIS compressor the piston of an internal-combustion engine performs a dual function; power being developed on one face of the piston while the opposite face compresses the air. The intermediate mechanism usually employed between the power and compressor pistons is thus eliminated. The piston is therefore known as a "free" piston, because no true connecting rod is used. Fig. 1 illustrates the principle of such a machine.

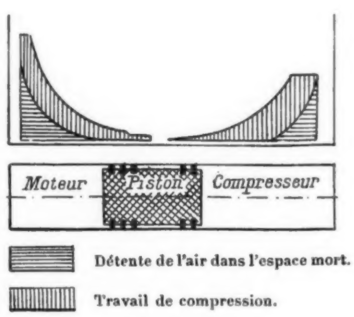

FIG. 1 PRINCIPLE OF THE AUTO-COMPRESSOR

(Horizontal sectioning indicates work of the air expanding in the clearance space; vertical sectioning indicates work of compression.)

When the piston is projected to the right by the explosion, its kinetic energy is transmitted to the air which is being compressed. The piston is returned to the left by an expansion of the air in the clearance space of the compressor.

In such a machine the pistons constitute the flywheel and the velocity and number of strokes per minute are functions of the mass of the piston; the velocity of the piston is greater during the forward stroke (to the right) than during the return stroke, because the pressure on the piston is greater.

Such a machine is balanced by locating in the same motor cylinder two opposed pistons having the same masses and moving with the same velocities in opposite directions. The center of gravity of the masses in motion does not shift and hence no reaction is transmitted to the frame of the machine. In the case of a two-stroke-cycle engine there is a further advantage that the losses through the jackets are reduced. The scavenging air circulates in the same direction as the gases of combustion, which facilitates the process of scavenging. Governing is by control of the quantity of fuel which is properly proportioned with respect to the air output of the machine. The working stroke of the piston depends on the quantity of energy developed by the engine, while the energy for returning the piston is supplied by the expansion of the air in the clearance space. This varies with the length of the stroke of the piston which, in turn, depends on the quantity of air

remaining in the clearance space. The result is that if, for example, the machine is adjusted to run at half load and begins to be driven at full load because of the increase of the demand for air, the return-stroke energy may be insufficient to insure the return of the piston to the position where the ignition takes place in the engine. To avoid this the Pescara compressor employs a special device. Fixed pistons are installed at the ends of the cylinders so that between the fixed piston and the moving piston there is a certain amount of air. During the working stroke this air stores up a certain amount of energy and returns it to the working piston on the return stroke. This energy varies directly with the stroke which can be varied to compensate for the change in energy derived from air stored in the clearance spaces. A proper return of the motor piston is thus assured for all rates of operation.

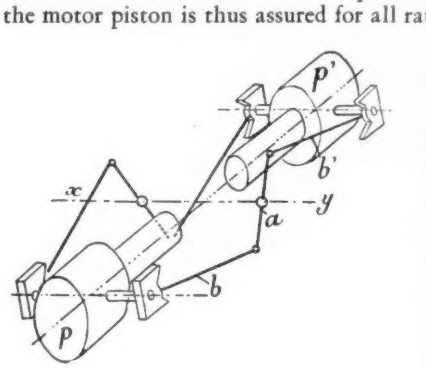

FIG. 2 DEVICE FOR SYNCHRONIZING THE PISTONS
(a, balancing crank; b b', connecting rods; p p', pistons; x y, fixed axis.)

Fig. 3 shows a simplified section of one of these compressors. An apparatus delivering 1.600 cu m (56.5 cu ft) of free air per min at a pressure of 7 kg per sq cm (99.5 lb per sq in.) has an engine bore of 90 mm (3.54 in.) and a compressor bore of 180 mm (7.08 in.). The fixed piston which produces the effect of a compensating spring

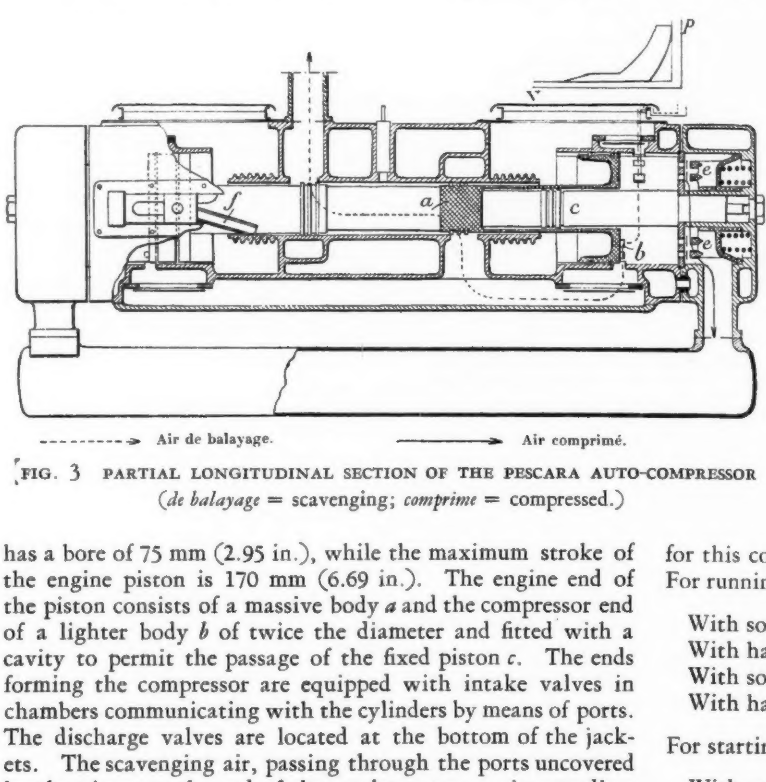

FIG. 3 PARTIAL LONGITUDINAL SECTION OF THE PESCARA AUTO-COMPRESSOR
(*de balayage* = scavenging; *comprime* = compressed.)

has a bore of 75 mm (2.95 in.), while the maximum stroke of the engine piston is 170 mm (6.69 in.). The engine end of the piston consists of a massive body a and the compressor end of a lighter body b of twice the diameter and fitted with a cavity to permit the passage of the fixed piston c. The ends forming the compressor are equipped with intake valves in chambers communicating with the cylinders by means of ports. The discharge valves are located at the bottom of the jackets. The scavenging air, passing through the ports uncovered by the piston at the end of the stroke, enters an intermediate chamber where the scavenging-air discharge valves are located, and thence into a reservoir of scavenging air.

The cycle of the apparatus consists of the following parts: (1) Compression continuing up to the opening of the scavenging-air discharge valves; (2) exhaust of scavenging air up to the closing of the ports by the pistons; (3) compression of the remaining air up to the opening of the discharge valves; (4) exhaust of compressed air to the reservoir; (5) expansion of compressed air in the clearance space; (6) opening of the intake valves essentially at atmospheric pressure and filling of the compressor cylinders.

While the principle of functioning involves no direct connections between the pistons themselves or the pistons and the rest of the mechanism, it is necessary in order to maintain balance to synchronize the movements of the piston. This synchronization is accomplished by two pairs of connecting rods f, Fig. 3, between crossheads on the pistons and two symmetrical rotated cranks. These two cranks are also used to drive the injection and lubrication pumps. Fig. 2 shows diagrammatically the layout of this synchronization mechanism with the connecting rods b and b'.

It is claimed that this machine has been already applied in public works, mining, transportation, and the chemical industry. (*Le Genie Civil*, vol. 102, no. 4, Jan. 28, 1933, pp. 91–92, 3 figs., *d*)

APPLIED MECHANICS

Friction of Screw Threads

FRICTION research in connection with machine elements has been confined very largely to the cylindrical bearing. Very few tests have been made to determine the friction loss in power screws; and none, as far as the authors are aware, has been reported within the past thirty-five years. The chief object of this investigation was, therefore, to determine values for coefficients of friction applicable to the present-day operation of power screws.

The screw may be used in practice either as a means of performing work or for the purpose of binding and holding together various parts of machines or structures. In the latter case the thread is generally V-shaped and its pitch and depth conform to generally recognized standards. In the former case the Acme thread has superseded the square thread as the common and approved form, and while the proportions of the thread have been standardized, no standard of pitch is strictly adhered to.

The results of these tests are summarized as follows:

(1) The coefficient of friction of a plain collar thrust bearing such as may be used with a power screw is independent of load and speed within the range of common practice. Average values for this coefficient are as follows:

For running friction:

With soft steel on cast iron	μ = 0.121
With hardened steel on cast iron	μ = 0.092
With soft steel on bronze	μ = 0.084
With hardened steel on bronze	μ = 0.063

For starting friction:

With soft steel on cast iron	μ = 0.170
With hardened steel on cast iron	μ = 0.147
With soft steel on bronze	μ = 0.101
With hardened steel on bronze	μ = 0.081

(2) From these results it may be assumed that, for average conditions, the coefficient of starting friction may be taken as about $1^1/_3$ times the coefficient of running friction.

(3) The combination of hardened steel on soft steel was found to be unsatisfactory, since seizing, or "galling," occurred at comparatively low pressures.

(4) It was found that the friction of ball thrust bearings is so small that it may be considered negligible in connection with power screws. (Clarence W. Ham and David G. Ryan, *University of Illinois Bulletin*, vol. 29, no. 81, June 7, 1932, also listed as Bulletin No. 247 of the Engineering Experiment Station, University of Illinois, 60 pp., 26 figs., *e*)

On the Atomization of Liquid Jets

THE author claims that up to the present no completely satisfactory explanation of the mechanics of atomization of liquids by forcing them through small orifices has been made. One explanation is that atomization is caused by the turbulent motion of the liquid as it leaves the orifice. Another is that the gas into which the fluid is injected causes the atomization. The author tests the first of these explanations by applying dimensional reasoning to obtain an equation for the mean angular velocity of the fluid as it leaves the orifice and then applies it to the process of atomization.

One may think of the fluid as being divided into small regions, each having an angular velocity, and hence speak of the whole fluid as having a mean angular velocity. This mean angular velocity of the fluid depends only on the diameter of the orifice, the velocity of flow, and the density and viscosity of the fluid. A dimensional expression for the mean angular velocity in the above terms is obtained which, however, is valid only for geometrically similar orifices.

After the liquid leaves the orifice, centrifugal forces tend to break up the jet against the opposing force of surface tension, it being assumed that viscosity has a negligible effect during this process and that the result does not depend on the diameter of the orifice. This makes it possible to obtain a dimensional equation and a complete equation (Equation [3] of the original paper) for the mean diameter of the drop. It is next shown that the fluid can be in equilibrium only if the force of surface tension is greater than the centrifugal force, and a general expression for the necessary magnitude of rotation is derived by assuming that the volume of fluid has the form of a sphere, an assumption that is not exactly correct, however.

The author passes next to a consideration of experimental results obtained by R. Kuehn and published in the National Advisory Committee for Aeronautics, Technical Memorandums Nos. 329, 330, and 331. These results give a partial proof of the validity of the complete equation for the mean drop diameter just referred to.

Experiments by Dana W. Lee (National Advisory Committee for Aeronautics, Report No. 425) are also referred to.

The original article gives a table (Table 1) showing that the function of the Reynolds number in the complete equation for the mean drop diameter is a slowly increasing function having the same general behavior as an orifice coefficient. The results with kerosene do not appear to be strictly comparable with those for gas oil. The orifice coefficients C_0 are given in the table for purposes of comparison. The largest Reynolds number for gas oil is only a little smaller than the smallest for kerosene, but the orifice coefficients are quite different, a result not to be expected. The author concludes from this that the failure of the equation to agree for kerosene and gas oil may be due to differences in the experimental conditions rather than to inaccuracy in the equation.

The author points out the difficulty in the definition of a mean drop diameter in the equations and tables. If one neglects the function of the Reynolds number in the equation referred to, considering it to be a constant, then the product of the mean drop diameter and the cube root of the injection pressure should be a constant for a given liquid and orifice.

The problem of atomization has been studied mostly in connection with engines, the experimenters using oil. It appears, however, that a better experimental method is to use liquids which will solidify before coming into contact with any solid surface. The drops may be kept and studied at leisure. The author tried spraying melted beeswax using an atomizer in which the atomization depends on an air jet. The wax solidifies fairly quickly but not until it is atomized. The particles float like dust in the air. There appears to be some advantage in using alloys of low melting point. With such dense substances, the drop sizes and size distribution can be determined by sedimentation methods. This method may make it possible to obtain results of high precision. (H. B. Holroyd, in *Journal of the Franklin Institute*, vol. 215, no. 1/1285, Jan., 1933, pp. 93–97, *et*)

A Method of Interpolating Data Based on Duhring's Rule

DUHRING'S rule is usually stated as an empirical relation expressed by the equation

$$T_A - T'_A = k(T_B - T'_B)$$

or

$$T_A = kT_B + C$$

where T_A and T_B are the absolute boiling points of two substances at any one pressure; T'_A and T'_B the boiling points of the same substances at a different pressure; and k and C are constants. The same rule may be restated in a different way, as follows: If the temperatures at which two substances exert equal vapor pressures are plotted against one another, the points so obtained are found to approximate very closely a straight line. If complete data are available for one substance, it is necessary to know only the vapor pressures of another at two temperatures in order to draw such a straight line (frequently called the Dühring line) and to construct the complete vapor curve of the second substance. An illustration in the original article shows a convenient method of constructing a vapor-pressure curve from the known curve for another substance.

The authors introduce two other relationships. One is the empirical rule of Ramsay and Young and the other the relationship derived from the Clausius-Clapeyron equation, but assuming that the vapor obeys the perfect-gas laws and neglecting the volume of the liquid. Thus there are relationships between the vapor pressures of two substances expressed in the form of three similar linear equations between three different simple functions of the temperatures at which the vapor pressures of the two substances are equal. It becomes possible to apply each of these relationships to comparisons between similar substances with surprising accuracy. This makes it possible to construct the vapor-pressure curve of one substance from the known vapor-pressure curve of another by any one of the three methods, and thus to estimate not only the vapor pressures but other data dependent on the vapor pressures. The paper shows that the same regular procedure can be used to estimate data of many other kinds where satisfactory data for one substance or one system are available and those for similar substances are under investigation.

As an example of the application of this general method for

estimating data in the case of a complicated system, the case of an instrument used for the analysis of mixtures of fuel gas and air is taken. This is calibrated for fuel oil of one composition throughout the range from zero to 100 per cent of fuel gas. The composition of the fuel gas, however, is subject to frequent change which makes a single calibration curve almost useless. By determining the reading of the instrument with 100 per cent fuel gas and employing the general method outlined in the paper, using for reference a calibration curve made with gas of one composition, a complete calibration curve can quickly be drawn for fuel gas of another composition. The method is entirely satisfactory when the variation of the gas is not greater than the accidental variation in manufacture, but does not apply with enough accuracy to gases as different as carbureted water gas and natural gas.

The same method is applied to the determination of the heat of vaporization of one of a pair of substances by using the other substance as the reference substance. Phenomena of electrolytic conduction and particularly heat capacity can be investigated by the same process. It cannot be used, however, with water vapor and carbon dioxide, as the graph for this pair of gases is not linear but exhibits marked curvature. (J. H. Perry of E. I. du Pont de Nemours & Co., Cleveland, Ohio, and E. R. Smith, Bureau of Standards, Washington, D. C., in *Industrial and Engineering Chemistry*, vol. 25, no. 2, Feb., 1933, pp. 195–199, 11 figs., *d*)

ELECTRICAL ENGINEERING (See Special Processes: Photoelectric Control of a Paper-Cutter Register)

FUELS

Gasoline-Alcohol Blends

FOR the purpose of fostering a national farm-relief project based on the use of farm products to provide alcohol for motor fuel, a joint committee has been organized in Chicago headed by C. V. Gregory, editor of *Prairie Farmer*. Dr. Leo M. Christianson, of Iowa State College, will be technical adviser of the committee, which includes officers of the following organizations: American Farm Bureau Federation, Illinois Agricultural Association, National Grange, Farmers' Equity Union, Farmers' National Grain Corporation, and the Indiana and Iowa State Farm Bureau Federations.

Chairman Gregory issued the following statement at the organization meeting: "A more permanent step in the program of national relief is the plan to require by law that all gasoline used in motors be diluted with a 10-per cent mixture of grain alcohol, thus creating a new market for 680,000 bushels of grain a year."

A bill has been introduced in both houses of the Iowa State Legislature assessing a tax of 10 cents per gallon on all motor fuels sold in Iowa which do not contain at least 10 per cent of alcohol made from corn, barley, or rye. The measure represents the third phase of legislation in Iowa tending to add grain alcohol to gasoline as a motor fuel under state control and regulation. Previous provisions enacted into law include an enabling act to permit the manufacture of the alcohol in the state.

In this connection Warren N. Watson, Chief of the Chemical Division, U. S. Tariff Commission, in 1930, presented the results of a comprehensive study of costs of producing industrial alcohol from various sources. He studied an estimate made by petroleum technologists to the effect that an average cost of less than 20 cents per gal for ethyl alcohol produced by cracking of fixed refinery gases. He presented also a table of the miscibility temperatures of gasoline-alcohol blends. The miscibility temperature of gasoline and ethyl alcohol is lowered by the addition of butyl alcohol. (*The Oil and Gas Journal*, vol. 31, no. 40, Feb. 23, 1933, pp. 12 and 56, *g*. See also "Alcohol-Gasoline Mixtures as Motor Fuels" on pp. 285–286 of this issue.)

Colloidal-Fuel Research

THE London members of the Society of Consulting Marine Engineers and Ship Surveyors had the opportunity, on January 25, of hearing particulars of the work carried out by Stephen L. Wyndham, of Cardiff, on colloidal fuel. In the experiments which Mr. Wyndham is conducting, and which he described at the meeting, he deals with the coal from the duff size (washed). The 60 or 70 per cent by weight is placed in what is termed the raw-coal bin, from which it falls by gravity into the first mill. Here it is reduced to the fineness of 100 per cent through a 100-mesh and 85 per cent through a 200-mesh screen. It then falls into the mixer which contains the percentage of oil by weight to be used in the colloidal mixture, and thereafter is passed through the so-called superfine mill, which brings about a very intimate binding of the oil to the coal substance. One of the difficulties which are likely to be encountered is coking of the fuel at the burners. Mr. Wyndham's design of burner appears satisfactorily to prevent the temperature of the tips rising above the burning point of the fuel, so that the usual coking trouble is apparently eliminated. (*Shipbuilding and Shipping Record*, vol. 41, no. 5, Feb. 2, 1933, p. 103, *d*)

INTERNAL-COMBUSTION ENGINEERING (See also Special Machinery: Rocket Motors)

Indirect Air Cooling

BY INDIRECT air cooling of internal-combustion engines is meant a system wherein the radiator size is reduced and may possibly be eliminated by the use of a cooling liquid having a high boiling point. Preliminary tests on this method were conducted at the Naval Aircraft Factory in Philadelphia, in 1925, on stock aircraft engines. It was found that the reduction in radiator capacity made possible was only partly due to the higher mean temperature of the radiator and in considerable measure to the increase in direct radiation from the engine jacket.

The next step was the construction by the Comet Engine Company of an engine specially designed with this system of cooling and working with a compression ratio of 6.25 to 1. In the first design no provision was made for forced circulation of the coolant, but fore-and-aft as well as cross circulation was recognized to be desirable, and the jacket therefore was widened at the upper (crankcase) end of the block to permit circulation past the cylinder walls at this point. The other fore-and-aft passage was under the cylinder heads. The passage at the upper end of the block was intended also as an expansion chamber. To prevent loss of liquid as much as possible, only one opening was left into the jacket, and this was fitted with a pressure-relief valve.

Several troubles developed but were largely corrected. As the average temperature of the coolant increased from 180 F (with water cooling) to 340 F, the volumetric efficiency decreased from 74 to 71 per cent, and the oil temperature rise increased from 67 to 72 F. Among other things, a certain amount of warpage developed which may be ascribed, however,

to defects in castings. The chief advantage of the indirect air-cooled engine over a radial air-cooled one is the reduction in air resistance. It is now proposed to make the indirect air-cooled engine of a streamline form with the tail cowl which can be used to house the power shaft and accessories. The title of the article, "Indirect Air Cooling Problems Not Solved But Solvable," expresses the present situation. (Paper by J. H. Geisse, Comet Engine Co., before S.A.E. annual meeting, Detroit, Jan. 23 to 26, 1933, abstracted through *Automotive Industries*, vol. 68, no. 9, March 4, 1933, pp. 277–278, 2 fig., *d*)

LUBRICATION

Top Lubricants

BY TOP lubricants is meant lubricants which are added to the gasoline. The article reports a test over a distance of 10,000,000 miles given top lubricants by Greyhound buses. The Greyhound fleets have used two types of lubricants in gasoline. One is an oxygenated Pennsylvania oil processed in such a way as to form certain synthetic compounds resembling natural fats and claimed to have a high degree of oiliness. The other product is a synthetic lubricant.

Results observed by W. A. Duval, superintendent of maintenance, and B. G. Spice, in charge of gasoline and oil purchases, due to the addition of top cylinder lubricant to gasoline for heavy-duty bus engines, are: (1) Increases in gasoline mileage from 4 to 8 per cent, (2) increases in crankcase oil mileage cumulatively to as much as 100 per cent, (3) reduced carbon formation, (4) prevention of frozen piston rings and sticky valves, (5) reduced valve grinding, and (6) reduced run-in time on engines after overhauls.

With heavy-duty bus engines, valves presented a serious maintenance problem before top lubricants were used. At the end of 15,000 miles, when heads were pulled, valves invariably were in poor condition. Under the high operating temperatures valves tended to pick up metal from valve seats, causing pitting and blow-by.

Since using top oils, standard shop practice is to give the valves only a light grind—a "touch-up," as the shop men call it. In the past three months at the Boston garage only one head has been pulled between regular overhauls because of sticky valves. In this case only one cylinder was causing trouble.

An important item of maintenance expense formerly was because of cracked cylinder heads caused by high operating temperatures. This expense has been reduced materially also. It is claimed that other advantages were also obtained, particularly saving in the use of gasoline. (J. C. Chatfield, *National Petroleum News*, vol. 25, no. 6, Feb. 8, 1933, pp. 31–34, 3 fig., *pt*)

MARINE ENGINEERING (See also Fuels: Colloidal-Fuel Research)

The New Isherwood Hull Form

IT IS claimed that with this form of ship hull a speed of nine knots can be attained with twelve tons of coal. Corresponding economies are attainable at higher speeds. The new form is said to be a radical departure from orthodox practice. In this case the modification concerns particularly the midship section contour.

Sir Joseph Isherwood took, as a beginning, his new middle-body portion and attached to it the forward and after ends of an actual vessel known to be giving satisfactory results in practice. It was found by tank experiment at the National Physical Laboratory at Teddington that the first of his contentions was proved, with the addition of an incidental 180 tons of displacement, secured by 3-in. deeper immersion permissible by the new form. While the new form naturally required proportionately greater power for a reasonable range of speeds, it is said that the new form has, in effect, maintained the efficiency over a range of three knots, inasmuch as the resultant Admiralty constant was not reduced by more than 2 per cent between the range of speeds of 9 and 12 knots. This can fairly be said to establish the principle of the change of the middle body portion of the ship which carries the bulk of the displacement.

The model tested was for a vessel 395 ft long. Afterward, a further model was made by adding some 220 tons displacement without altering the predetermined midship section contour. It was found, substantially, that no more power was required to drive the vessel, at corresponding speeds in the former model, over the range of 9 to 12 knots, while the resultant Admiralty constant did not vary more than 5 per cent in the range of speed of 9 to 12 knots, being 409 at 9 knots and 389 at 12 knots, both figures being based on indicated horsepower. This was further proof that within a fairly wide range of speeds of 9 to 12 knots it was not necessary to sacrifice efficiency. Sir Joseph then had a third model with a further additional 250 tons of displacement. Again, the resultant Admiralty constant was exceptionally high, and with a reduction of less than 4 per cent between speeds of 9 and 2 knots.

It is Sir Joseph's view that while the forward and after lines of a vessel are of great importance, naval architects have not given sufficient consideration to the relatively greater middle body portion of the ship and its ultimate effect on the stream or flow lines of water past the bulk of the ship. In other words, the most economical stream lines were not obtainable through attention to the fore and aft lines only. No further information as to the actual shape of the new hull is given. (*Shipbuilding and Shipping Record*, vol. 41, no. 5, Feb. 2, 1933, pp. 105–106, *dA*)

The Water-Tube Boiler of the Cargo Ship

THE authors consider primarily the cargo ship of the tramp class. They state, on the basis of a paper given by J. Johnson in 1932 before the Institution of Naval Architects, "Fuel for Merchant Ships," that fuel is the deciding factor in cost of operation of the ship and that machinery type is really a secondary consideration.

Arising from this fundamental statement, the oil engine is at once circumscribed by its own peculiar limitation, i.e., it runs on oil only and on high-grade oil at that. In other words, a steamer possesses the salient advantage of being able to use whichever fuel—oil or coal—happens to be the more economical for any particular service. The tramp is essentially the general-service ship of the seven seas, which means that the economical tramp must possess the greatest possible flexibility to operate on whatever fuel offers.

Yet the motorship claims supremacy and we are continually told, not only by partizan interests, but also by people who have "no ax to grind," i.e., shipowners themselves, that they find their motorships more economical than their steamships. How are we to correlate these apparently contradictory statements, both superficially capable of infallible proof? The reply does not need much seeking: it is that almost without exception when this decision in favor of Diesels has been arrived at, the comparisons have been made between modern motor

tonnage and steamships whose fundamental machinery design is still some twenty years old.

What can modern steam offer to cargo-ship owners without undue complication and at an installation cost of something less than that of the up-to-date oil engine? Expressed briefly, up-to-date steam machinery for an ordinary cargo ship of, say, 2000 to 2500 shp can offer 1 lb of average bunker coal of, say, 13,500 Btu per lb per shp for all purposes, and with the same machinery and rating and without dismantling the equipment, 0.7 lb of oil of, say, 19,000 Btu per lb for the same duty. Where traffic takes place regularly to ports where Diesel oil is cheap, the Diesel engine is superior. It does not apply to traffic in ports where the Diesel-to-boiler-oil differential is wider, or where good bunker coal is cheap.

The authors consider next two main factors in modern steam propelling machinery. From a consideration of these factors the disadvantages of the modern Scotch boiler, even when fitted with air heaters, are first, that it is not amenable to construction for pressures exceeding 300 lb per sq in., and second, it is not easily adopted to mechanized firing.

The following passage is quoted verbatim: "Having in view the universal adoption of the water-tube boiler for naval work, and to a great extent for modern passenger and mail tonnage, the reasons advanced by the tramp-ship owner against the water-tube boiler are very difficult to appreciate. Quite frequently well-informed executives state that water-tube boilers are totally unsuited for their particular service. They speak of high maintenance charges, burst tubes, and heavy expense in dealing with the feed problem, and as a result fall back again on medium pressures as offered by the Scotch boiler, and so automatically prevent themselves for taking advantage of modern plant. These exaggerated difficulties are dealt with by the authors a little later. The point is, can the merchant service, with its back to the wall, and fighting for its existence, afford to be guided by this type of mentality, particularly when drastic changes in the design of machinery, etc., which can be economically justified, were never so called for as they are today.

"Considering the matter in further detail, it would appear that the only important factor which really worries shipowners in changing over from Scotch boilers to water-tube boilers is the matter of the feed. Here again, it is probable that this gets looked at with an exaggerated idea of its dangers and difficulties, as with a medium-rated water-tube boiler with fire-row tubes of reasonably large diameter, the dangers due to impure feed are certainly no more acute than those which would appertain to a Scotch boiler under like conditions. On the other hand, no one will question the fact that good feed is essential to all types of boiler if maintenance costs are to be kept down and efficiency maintained."

The authors consider next the cause of feed troubles at sea, but come to the conclusion that the water-tube boiler is as simple, fool-proof, and easy of access and control at 500 lb pressure as at 180 lb.

The question of choice of the best type of mechanized firing for the tramp ship is next discussed. The requirements that an ideal marine firing system should satisfy are presented. Reference in this connection is made to the Babcock & Wilcox experimental marine plant at Renfrew. The authors claim that by taking advantage of what modern steam can offer, the ordinary cargo ship can operate on 20 to 25 per cent less fuel consumption than obtains with the ordinary cargo ship at present afloat. (Paper by Engr. Rear-Adm. W. N. Whayman and Maj. W. Gregson before the Northeast Coast Institution of Engineers and Shipbuilders, abstracted from advance copy, 20 pp., 9 figs., *dc*)

MOTOR-CAR ENGINEERING

Lower Licenses for Restricted Areas

THE British Minister of Transport has before him a scheme for the issue of licenses at reduced rates when vehicles are to be operated only in specified areas. The idea is to employ specially designed low-powered vehicles of approximately two tons to be run only within restricted areas, for example, dock districts. Such vehicles would bear some particular identification mark and would not be permitted to be employed outside of the prescribed area. It is suggested, for example, that London could be divided into, say, three areas with a maximum radius of ten miles. (*The Commercial Motor*, vol. 56, no. 1455, Feb. 3, 1933, editorial on pp. B15–16, *g*)

Gear Shift by Torque Reversal

AN AUTOMATIC shift transmission in which the shift between gear speeds is accomplished silently and positively without the introduction of any other actuating means than torque reversal has been developed by Oscar H. Banker, with the backing of the Magill-Weinsheimer Co., of Chicago.

Called the Mono-Drive, this transmission permits the elimination of both clutch pedal and gearshift lever from the car, and for normal driving the only controls used are the accelerator and brake pedals and the steering wheel.

Shift from low into second and from second into high is accomplished by releasing the accelerator pedal briefly. The shift from low into second in the transmission in the car which the author drove could be accomplished at any speed above 5 mph, while from second to high it could be made anywhere above 9 to 10 mph. On the other hand the car could be accelerated in low up to some speed above 10 mph and shifted directly into high by releasing the accelerator pedal for a longer interval. Also, the car could be accelerated in second speed up to 40 to 45 mph if desired, before shifting into high.

A dash control is provided for reverse engagement and places the transmission in neutral. There is no master clutch in this system but instead a series of internal expanding brake-type clutches for engagement of the various speeds. The engagement of these clutches is centrifugal but almost instantaneous in action in the case of second speed and high, so that there is a minimum of slippage.

Basically, the transmission is of the planetary type, with the planetary carrier mounted in such a manner that when torque is applied it is stationary, and reaction is taken by the case, while when torque reverses, the carrier can move through the provision of an overrunning clutch.

The action is explained in detail by the illustrations in the original article which cannot be reproduced here because of lack of space. (Athel F. Denham, *Automotive Industries*, vol. 68, no. 7, Feb. 18, 1933, pp. 197–199, 7 figs., *d*)

PETROLEUM ENGINEERING

Developments in Pumping Machinery and Methods

THE article deals with the present tendency in the development of new methods in the production of crude oil. It pays particular attention to methods of pumping.

During the past five years the depth from which oil must be produced has increased from 4500 ft to around 6500 ft. No major pools have yet been discovered at greater depths in Kansas and Oklahoma, but wildcat wells of 7000 or 8000 ft are no longer a novelty. It is entirely logical to expect that within

the next five years producers in the Mid-Continent fields must solve the problem of lifting oil from these depths by some means which will yield a profit to themselves. Lower market prices have forced the operator to investigate his producing methods carefully, seeking for more efficient equipment with which to produce from present depths.

In view of the unfavorable conditions which have existed throughout the past two years, it is indeed astounding to look at the progress which has been made in producing methods even during the times of economic stress. In the first place, the fast increasing realization that formation gas energy is the most important agent in the recovery of oil has led producers to strive for its conservation by all the means at their command. Open flow of wells has very largely given way to restricted methods, in which chokes or tubing are employed to back-pressure the reservoir and control the ratio of incoming gas to oil. Engineering practice has developed a better knowledge of the principles underlying movement of gases and liquids through reservoir sands and through pipes. With this information, the producer can confidently expect wells to flow on their own energy for a much greater length of time and, what is more important from this point of view, secure an increased ultimate yield of oil.

Gas lift methods have been developed and tried which extend their application to very small and very deep wells. The application of chamber lift and plunger lift reduce the number of working parts in a well to only one. Small tapered or straight flow strings require no moving parts. Chamber lift can be used on wells with little or no formation pressure and when used with automatic intermitters, eliminates to a great degree the human equation. When used with fluid-level timers, the well determines its own rate of pumping. Plunger lift reduces the necessary working pressure to a minimum and the pressure required is practically independent of the height of lift.

Conventional pumping equipment is getting a thorough overhauling and redesigning which will certainly extend its field of application and promises much greater efficiency than ever before. Such features as submerged prime movers are attracting a host of experimenters and manufacturers who will eventually solve the problem, at least for certain types of work.

Particular attention is called to the technique of production men and operators. An understanding of a few fundamental laws governing the behavior of gas and fluids has given them a different conception of producing oil wells. Gas lift, tapered tubing, and bottom hole chokes all have some place in the modern producer's tool kit. They have been taken from the laboratory shelves and made into useful implements in which the production man has confidence. Chamber lift, plunger lift, and submerged prime movers will find their way into the tool kit in time. (Raymond M. Carr, Sinclair Prairie Oil Co. Paper before the American Petroleum Institute, Mid-Continent district meeting, Wichita, Kans., Feb. 17–18, 1933, abstracted through *The Oil and Gas Journal*, vol. 31, no. 40, Feb. 23, 1933, pp. 33–35, 7 figs., *d*)

POWER-PLANT ENGINEERING

Binary-Vapor Power Plants With Anhydrous Aluminum Bromide

ALUMINUM bromide is a solid with a melting point of 93 C and a boiling point of 267 C. Its density is 2.5 and critical temperature 722 C. It is not toxic, does not dissociate below about 1100 C, and has no corrosive effect on steel. Its vapor density is high (18.64 at 440 C) thirty times that of water vapor and twice that of mercury vapor, which makes it possible to employ slow-speed turbines. This simplifies turbine construction, as compared with that of steam-turbine construction, and does not require reduction gearing, which may be of importance in marine applications. Moreover, there are no commercial obstacles to the large-scale production of anhydrous aluminum bromide. Finally, unlike mercury, aluminum bromide wets steel, which assures better heat transmission and uniformity in vaporization. On the other hand, aluminum bromide has the disadvantage that it is very hygroscopic and combines powerfully with water. If this takes place at the comparatively low temperature of about 200 C, it is accompanied by decomposition with the

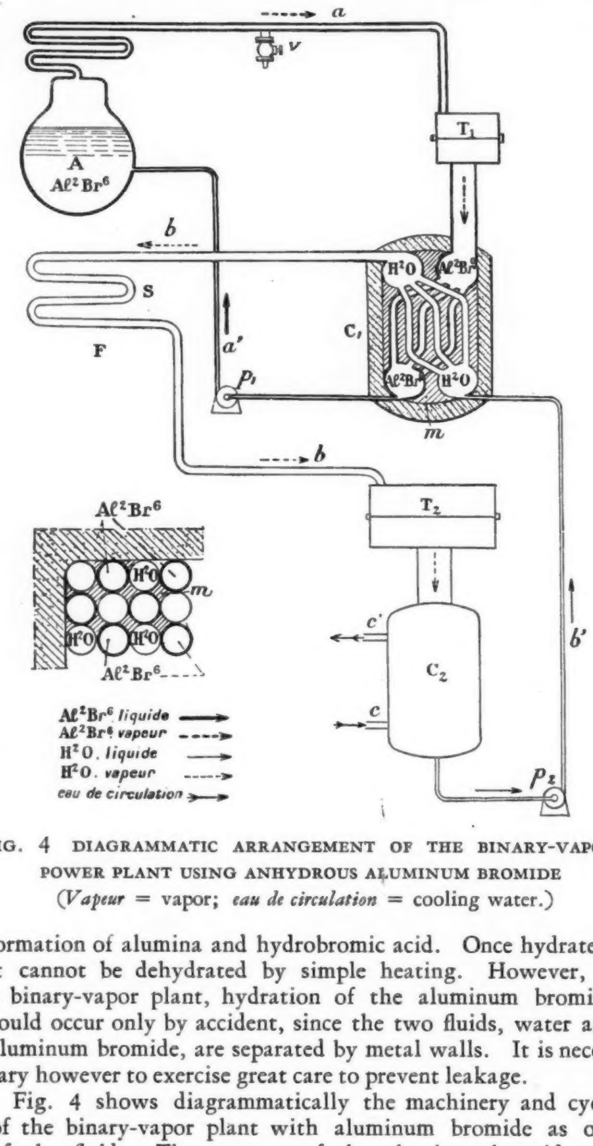

FIG. 4 DIAGRAMMATIC ARRANGEMENT OF THE BINARY-VAPOR POWER PLANT USING ANHYDROUS ALUMINUM BROMIDE

(*Vapeur* = vapor; *eau de circulation* = cooling water.)

formation of alumina and hydrobromic acid. Once hydrated, it cannot be dehydrated by simple heating. However, in a binary-vapor plant, hydration of the aluminum bromide could occur only by accident, since the two fluids, water and aluminum bromide, are separated by metal walls. It is necessary however to exercise great care to prevent leakage.

Fig. 4 shows diagrammatically the machinery and cycle of the binary-vapor plant with aluminum bromide as one of the fluids. The pressure of the aluminum-bromide vapor may be maintained in excess of atmospheric pressure throughout the cycle so that leakage is instantly indicated by the intense smoke which aluminum bromide creates when it combines with moisture in the air. The addition of dry nitrogen under pressure will completely insulate aluminum bromide. In order to ensure tightness of the condenser-boiler C_1 and effective transmission of heat between the two fluids, a special arrangement of pipes, as shown in the lower

left-hand corner of Fig. 4, may be used with a plastic metallic packing *m*, such as lead, for example, or a fusible alloy of lead and tin with or without bismuth.

Fig. 4 shows diagrammatically the arrangement of a binary-vapor power plant using water and aluminum bromide. *A* is the aluminum-bromide boiler producing a vapor at 500 C (932 F) and 12 kg per sq cm (170 lb per sq in.); *a* is the pipe leading to the first turbine T_1; C_1 is the condenser and heat exchanger operating at 290 C (554 F) and a pressure on the bromide side of 1.2 kg per sq cm (17 lb per sq in.). C_1 also acts as a boiler producing steam at a pressure of 30 kg per sq cm (426.6 lb per sq in.); *S* is the superheater of the steam receiving its heat from furnace *F;* T_2 is the steam turbine, and C_2 its condenser at a temperature of 25 C, with a cooling-water circulation *cc';* p_1 and p_2 are feedwater pumps for the boiler *A* and the condenser-boiler C_1, respectively; *V* is the automatic nitrogen admission valve.

Aluminum bromide can be obtained in practically unlimited quantities. Its production and cost depend directly on the cost of the bromine which constitutes 90 per cent of the weight of the aluminum-bromide molecule. In addition to sea water in which the bromine content on an average is 0.67 grain per liter of water (0.04154 lb per cu ft), the metalloid is encountered in comparatively large amounts, such as three parts in a thousand, in the lye of potash mines. It is easily extracted by a flow of chlorine, and unrefined bromine containing a small quantity of chlorine may be used for the preparation of aluminum bromide which is produced simply by burning metallic aluminum in bromine vapor. It would appear, therefore, that the manufacture of the salt on a large scale should not be very costly. It is estimated that Alsatian potash mines have a reserve of bromides of the order of 2.4 billions of tons and it should be noted that at present there is practically no other source where bromine could be employed. (H. Barjot, *Le Genie Civil*, vol. 102, no. 1, Jan. 7, 1933, pp. 13–14, 2 figs., *d*)

PUMPS (See also Petroleum Engineering: Developments in Pumping Machinery and Methods)

Wee-Mac Self-Priming Pump

THIS pump was developed for delivering small quantities of water to considerable heights or pressures, and is built in capacities from 120 to 300 gal per hr and for heads from 15 to 150 lb per sq in. The builders are Drysdale & Co., Ltd., Yoker, Glasgow, Scotland. It is claimed that the pump evacuates air from the suction pipe without difficulty, and as it develops a head about three times that of an ordinary centrifugal pump of the same size, the introduction of more than one stage is only necessary when a high head is required at a relatively low speed.

The pump resembles an ordinary centrifugal model in that it has a casing fitted with suction and discharge pipes and an impeller mounted in the conventional manner. The pump, however, is always arranged with both the inlet and discharge branches at the top. The fluid enters the impeller near the center and leaves at the periphery. The central portion of the impeller takes no part in the pumping action, the latter being entirely performed by a series of buckets cast around the rim. The impeller is mounted between two side plates in the casing, which is concentric with the axis of rotation. The side plates have plain inner faces in which two water channels are cut, one in each plate, concentric with the path of the blading. The channel on the suction side, starting with the full area, gradually narrows until it dies away flush with the sides of the blades, the total length of the passage being about three-quarters of the circumference of the blade path. The outlet channel is similar but in the reverse direction, the two channels, in effect, constituting a continuous canal passing obliquely through the impeller. The arrangement will be clear from Fig. 5 showing a development of the passages and blading.

Assuming that the impeller is revolving, it will be evident from Fig. 5 that after the buckets have passed the end of the suction passage, the water must leave entirely on the discharge side. Pressure will, therefore, be built up at the wider end of the discharge passage. Owing to the narrowing width of the suction passage, the same effect will take place, to a reduced extent, before the buckets reach the point referred to, and as a result the pressure throughout the length of the discharge passage will be higher than that in the inlet passage, with a gradual increase toward the large or delivery end.

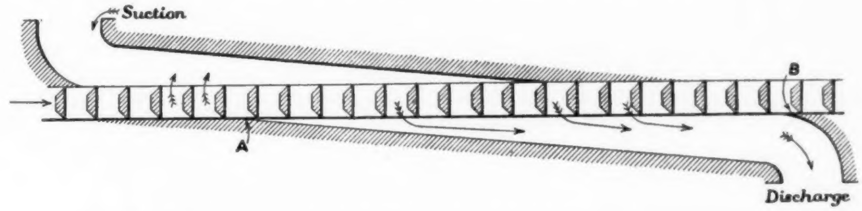

FIG. 5 DEVELOPMENT OF PASSAGES AND BLADING IN THE WEE-MAC PUMP

Owing to this difference in pressure between the two sides of the impeller, water will flow back through the blades at the following end as shown by the arrows, and the jets leaving the impeller in this way entrain any air which may be present on the suction side, this air being subsequently carried through and delivered on the discharge side. It will be appreciated from what has been said that a progressive rise in pressure occurs in each bucket as it travels from the suction to the discharge opening, giving a multi-stage pumping effect with a high discharge pressure.

Tests have shown that static suction lifts up to 28 ft are practicable, while if the pipe is completely closed it is stated that the suction effort of 32 ft can be obtained at sea level under normal barometric conditions. It is therefore not necessary to exercise special care in the suction-pipe layout as a continuous upward slope is not essential. (*Engineering*, vol. 135, no. 3501, Feb. 17, 1933, pp. 202–203, 5 figs., *d*)

RAILROAD ENGINEERING

Wind-Tunnel Development of a Proposed External Form for Steam Locomotives

THE existing shape and arrangement of steam locomotives are such that smoke from the stack tends to sweep back along the boiler top and descend in front of the cab windows, seriously impairing forward vision. For the maximum degree of safety it is essential that the view from the cab, especially in a forward direction, should be unobstructed at all times. It is therefore desirable that some means be found for improving the manner in which the smoke is carried away from the stack. In addition to preventing the descent of smoke at the cab it is desirable that the external shape of the locomotive should be so modified as to result in a decreased air resistance,

in view of the growing demand for economical running at increasingly higher speeds.

The paper describes work done in the wind tunnel of the National (Canadian) Research Laboratories and discusses the steps whereby an improved external shape has been evolved for locomotives such that the smoke is lifted over the cab, thus making possible an unimpaired vision ahead.

A series of modifications in the shape of the model have been tested for their effect on resistance and air flow. Attention is particularly called to the modifications of the top of the boiler, as this modification was expected to be very beneficial as regards smoke removal by introducing smooth flow conditions behind the stack. A particular investigation was carried out in reference to smoke flow from which it has been found that the present conditions, such as the obscuring of a cab window by smoke, can be eliminated by giving the locomotive a proper shape. Among other matters the location of the bell has been carefully considered.

The model as finally modified is shown in the original in several views. It operates by inducing a layer of clean air under the smoke layer and by suitable cowling subsequently minimizes the intermingling of the smoke layer with the clean air layer. It introduces clean air along the boiler sides, which is ultimately swept upward in front of the cab windows. The modifications have been made with the idea of reducing turbulence and eddying and thereby cutting down the wind resistance as shown by the following results.

The value of $(R/V^2)100$ (resistance coefficient, where R is the wind resistance in pounds, and V the wind speed in ft per sec), has been reduced from 0.1089 to 0.0706, a reduction of some 35 per cent.

The feedwater heater has been placed in a new position as a result of considerations made by the operation department of the Canadian National Railways. This position is just ahead of the stack and partly lowered into the smokebox. From the top surface of this feedwater heater, a level platform is taken back on either side of the stack and runs in a smooth curve into the cowling, over the dome and turrets.

Application has been made for patents on the new design. (J. J. Green, *Canadian Journal of Research*, vol. 8, Jan., 1933, pp. 37–61, 23 figs., *eA*)

ROLLING MILLS

Tube-Reducing or Sinking Mill

THIS is a general discussion on the subject starting with the reference to the Tasker patent of some fifty years ago, following which the author considers the arrangement of two succeeding roll sets as used in American reducing mills at the present time. The small reduction by each pair of rolls of duo-type mills necessitates the use of a great number of roll sets because the stretching effect of the rolls in a duo-type reducing mill is very slight. The reasons for this are presented in the original article.

The author next describes a reducing mill embodying a universal mill of the continuous type in which each roll set consists of four rolls in one plane, which enclose the surface of the tube and reduce it in one operation without using a mandrel. Such a tube-reducing mill was developed about ten years ago by the German engineer Stueting.

In contrast to the duo-roll pass, in which the broadening of the tube and the upsetting of its wall are simultaneously effected at two opposite sides, the new mill provides a four-roll pass by which the widening effect of the roll grooves is distributed over four places. In the four-roll type of mill the tube is almost entirely enclosed by the roll grooves. It is for this reason that the power required to operate this mill is almost completely utilized for stretching work. The greatest advantage claimed for the four-roll-type reduction mill over the duo-type machine is the much greater reduction per roll set. The practically insignificant widening of the tube during the rolling operation is neutralized by the slight differences in circumferential speed of the individual rolls in the four-roll pass. The natural thickening of the tube wall is neutralized by the slight pulling effect between the various roll sets. Only in the overhanging tube ends the upsetting tendency of the tube wall cannot be radically counteracted because sufficient pull is not available. Even though this condition does not exceed the tolerance limit, an endeavor must be made to dispense with it. Extensive experiments in this direction have already yielded favorable results.

In one design of the Stueting mill the horizontal drive lies on one side so that only one main drive shaft is required. The entire machine is built above floor level and is therefore very accessible.

The author also refers to a combination of a push bench and a four-roll-type reducing mill and believes that by this machinery seamless tubes of small and medium size can be manufactured more profitably than is possible at present. The reducing capacity of such mills is given in the original article. (W. H. Engelbertz, *Rolling Mill Journal*, vol. 7, no. 2, July-Aug.-Sept., 1932, pp. 81–84 and 114, *d*. In this connection attention is called to the article by G. B. Lobkowitz in the same issue, pp. 98–106, and page of illustrations, entitled "The Fundamentals of Continuous Tube Rolling," *mA*)

SPECIAL MACHINERY

Rocket Motors

THE author gives a general discussion of the subject of a non-mathematical character and some data of the history of the development of rocket motors and their present standing.

Experiments made up to about 1929 appear to have clearly indicated that the solution of the problem is not the employment of a rocket wherein the explosive power is supplied by powder. In 1929 Professor Oberth called attention to the possibilities of a liquid-fuel type of rocket as well as one in which hydrogen and oxygen in predetermined proportions are used. It was shown theoretically that with such a fuel the exit velocity of gases of the order of 4000 m per sec (13,123 fps) may be obtained.

Valier, who did much testing and design work about that time, was killed in 1929 in a rocket test, but his work was taken over and since then carried on by the Berlin rocket investigator, Rudolf Nebel, and his associates, working under the auspices of the Industrial Gas Improvement Company. A field for rocket testing was secured in the neighborhood of Berlin and a building containing the laboratories and engineering offices secured.

The main shops are surrounded by earthworks, 10 m (32.8 ft) high and 8 m (26.2 ft) wide to protect outsiders against any explosion that might occur. From the top of the wall a bridge leads directly into the test room. The rocket-testing apparatus is set in a ditch 12 m (39.4 ft) deep where the nozzle test stand is also located. Various other precautions against the danger of explosion have been provided. For example, the experimenter can safely observe the rocket explosions through a peep-hole or periscope.

For the time being the application of rockets for land transportation has been completely abandoned and all the work is

concentrated on the application of liquid-fuel rockets to aircraft.

Theoretically, a rocket motor should permit a gas flow at the exit from the nozzle at a speed of at least 1150 m per sec (3772 fps), or 4140 km per hr (2572 mph) which seems very high indeed. However, a velocity of 1150 m per sec has already been indicated in the case of a rocket motor using gasoline and liquid oxygen and it is believed that a velocity of 4000 m per sec (13,123 fps) will be obtained with liquid oxygen and liquid hydrogen. It should again be noted, of course, that these figures apply not to the velocity of an airplane but to the velocity of the gases of combustion as they leave the exit of the motor.

The new rocket motor has the shape of an elongated cylinder. Separate piping is provided for the two fuels, liquid oxygen and alcohol, that are used. The combustion chamber is now built with a double wall and the spacing between the walls is used to deliver liquid oxygen under pressure, the purpose of this arrangement being to relieve the very high temperature of the combustion in the combustion chamber. In tests made the pressure in the combustion chamber varied from 7 to 22 atmos.

The flame projects from 1.5 to 2 m (4.92 to 6.56 ft) beyond the orifice of the nozzle. The new rocket reaction motor is expected to deliver 100 hp per kg of weight which is about 100 times as much as the performance of the present aircraft motors, and furthermore the rocket motor can operate in an airless void which the present aircraft motor cannot. (Dr. Martell, *Schweizer Aero-Revue*, vol. 8, no. 2, Feb. 15, 1933, pp. 26–28, *hdA*)

SPECIAL PROCESSES

Production of Electrolytic Copper Sheets

AFTER thirty years of experiments and research Sherard Cowper-Coles, of England, has evolved a practical process which enables sheets of pure copper of varying degrees of hardness and of any thickness to be produced in one operation direct from copper ingot partially refined. The process is one of electrolytic refining and deposition on a revolving drum. Various attempts made in the past to produce sheets by an electrolytic process have not been commercially successful for a number of reasons, some of the most important being: slowness of deposition; inferiority of the sheet to ordinary rolled sheet; low efficiency of the process; large proportion of scrap metal; an even gage (uniformity) could not be obtained; considerable floor space was required.

These difficulties are claimed to be entirely overcome by the Cowper-Coles process, and sheets equal to or superior to rolled sheets are produced. The process is one of building up, not breaking down, and therefore very thin sheets can be made as cheaply as thick sheets, except for additional labor in handling a greater number of sheets per ton. The new process enables the thinnest sheets to be produced of almost any size, for instance, 12 by 4 ft, and permits small units to be worked very economically.

Both in hot and cold rolling the amount of scrap is very considerable; varying with the gage; the thinner the gage the greater the amount of scrap. In the new process the amount of scrap is said to be reduced to about 1 per cent; but as it has been refined during the process of deposition it brings the highest market price. It is claimed that the copper can be made very hard without after treatment, that it can be used for spring contacts in place of phosphor bronze, while retaining the advantage of pure copper with its high electrical conductivity. The process can also be employed for the production of bimetallic sheets, such as copper sheet faced with tin of any desired thickness or nickel suitable for spinning or stamping. Copper sheets produced by the new process have on one side a high mirror finish, which in many industries is a great advantage. (A. Eyles, Manchester, England, in *Metal Industry* (New York), vol. 31, no. 2, Feb., 1933, p. 53, *d*)

Photoelectric Control of a Paper-Cutter Register

TO MAINTAIN the register of a cutter on a cement-bag-making machine, photoelectric control was installed sometime ago at the plant of the Jaite (Ohio) Paper Company by the General Electric Company. The equipment is designed to eliminate the necessity of the operator's continuing observing the cut and making suitable manual corrections.

To accomplish this automatically, a small register mark is printed on each bag at the point where it is desired to make the cut. As the paper passes through the machine this spot passes underneath an opening in the photoelectric-tube housing, causing a variation in the light passing into the tube, thus making it possible to indicate the exact time that the spot passes underneath the tube. The paper passing underneath the photoelectric tube is illuminated by an intense concentrated light beam.

In order properly to time the movement of the spot underneath the photoelectric tube a selector switch is driven from the roll carrying the cutter knife. This selector switch makes an integral number of revolutions with each cut of the knife, and accordingly when the cut is being correctly made the switch will always be in the same angular position when the spot passes underneath the photoelectric tube. If the spot passes underneath the tube before or after the selector switch reaches its proper position, it is necessary to initiate a correction in the position in which the cut is being made. This is accomplished by amplifying the impulse received from the photoelectric tube and applying it to the control grid of one or the other of two thyratron tubes.

The remarkable feature of this type of arrangement is its great sensitivity. For example, it is stated that the thyratron selected will pass current within a period of less than $^1/_{10,000}$ of a second, and in so doing will energize a relay which will initiate the proper correction in the relation between the cutter knives and the sheet of paper. It is possible to judge the length of cuts or to obtain a correction in the cut, because the cut is being made early or late, though in normal operations a correction will be made very infrequently as the equipment operates before the errors are allowed to accumulate to a large extent.

The operating speed of the foregoing machine is a maximum of 600 ft per min, or a maximum of 300 cuts per minute. It should be noted that when operating at 600 ft per min the time required for $^1/_{16}$ in. of paper to pass a given spot is approximately $^1/_{2000}$ of a second.

A diagram showing how the photo-cell mechanism adjusts register is given in the original article. (D. R. Shoults, Indus. Engg. Dept., General Electric Co., in *Electrical World*, vol. 100, no. 17, Oct. 22, 1932, pp. 562–563, 2 figs., *d*)

STEAM ENGINEERING

Evaporation From Superheated Water

ACCORDING to the laws of thermodynamics a liquid is in equilibrium with its vapor as long as the ratio of the masses of the two remains unchanged. In this case as many

molecules are emitted from the liquid into the vapor as come from the vapor into the liquid. In such a state the temperature and pressures of the two must be the same. This condition of equality ceases as soon as the equilibrium between the liquid and the gas is destroyed, that is, when a one-sided transfer of mass takes place, be it by evaporation or by condensation. This is of interest because of the fact that, as has been found in the precise temperature measurements of M. Jakob and W. Fritz, the temperature of boiling water exceeds by about one-tenth of a degree centigrade that of the saturated steam with which it is in contact. This so-called superheating of water has been explained by Bošnjakovic by suggesting that as a transfer of heat of vaporization at the evaporating surface presupposes a temperature drop in a thin layer of liquid directly in contact with the surface, the temperature of the liquid must be greater than that of the vapor that is generated.

The tests described in the present article have been carried out with this in view with the intention of determining quantitatively the functional relation between the rate of evaporation and the degree of superheat of the liquid. It was also desired to determine the mechanism of the superheating of the liquid in the proximity of the evaporating surface. By rate of evaporation is meant the weight of vapor generated in kilograms per hour per square meter of the evaporating surface. Since this latter could not be precisely measured when formation of steam bubbles took place in the boiling liquid, care was taken in all experiments to see that not a single steam bubble formed. Vapor generation therefore took place only at the free and entirely measurable surface, and is consequently referred to as *Verdunstung* (evaporation) rather than *Dampferzeugung* (steaming), the latter term denoting vapor formation from a boiling surface.

The liquid used for test purposes, namely, distilled water, was brought up to temperatures which were as much as 9 C above the saturation temperature, the purpose of this being the desire to work with as great a range of water superheats as possible. The water was therefore in a constant state of evaporation; otherwise, the tests were carried out at atmospheric pressure. The author describes the apparatus and the method of carrying on the tests.

The author came to the conclusion that in order to establish a comprehensive equation for the rate of evaporation as a function of the degree of superheat of the liquid, further tests would be necessary. He believes that in addition to the heat of evaporation the following factors have a pronounced influence on the rate of evaporation, namely, the state of flow and the thermal conductivity of the liquid. All the factors, therefore, which control the heat transfer affect this process. They are expressed in the coefficients proposed by Reynolds, Péclet, Nusselt, Prandtl, and Grasshof. The author uses the term *Siedeverzug* (delay in boiling). In general physics this term denotes the phenomenon of a liquid that does not boil although its temperature is higher than the saturation temperature of its vapor at the same pressure, and it is usually assumed that when the formation of bubbles begins the temperature of the liquid falls off to the normal temperature of vaporization. This does not always follow. For example, if water (as was done in the present series of tests) is made air-free, the temperature of the liquid may rise above the saturation temperature without causing boiling. However, should one or more steam bubbles suddenly form it will be noted that while the temperature of the water drops, it falls only to a level of from one to several points above the boiling temperature. At higher superheats it was found that suddenly only a few steam bubbles form, but their number increases so rapidly that the entire mass of water is affected and violent agitation of the apparatus is produced. While this is going on the temperature falls several degrees, but as soon as the water has calmed down, the temperature returns to its original value. The supposition that the delay in boiling may be eliminated by shaking was not confirmed in tests with deaerated water. Even with the high degree of delay in boiling, not a single vapor bubble formed, notwithstanding violent shaking of the apparatus.

The fact that boiling does not take place even when the temperature of the liquid is higher than the saturation temperature of its vapor for equal pressures is an indication that there exists such a phenomenon as delay in boiling. In how far the superheat decreases with the formation of bubbles, and to what extent delay in boiling may be obviated by shaking, depends essentially on the air content of the liquid.

Among the conclusions to which the author arrives is that the rate of evaporation increases slowly at first and then with increasing rapidity, depending on the increase of superheat of the water. The variation of the superheat was determined in a direction normal to the evaporating surface. The measurements showed that the superheat of water retains practically its full value to a depth of 2 mm, but from then on rapidly disappears. The temperature of the water vapor was found to be the saturation temperature and independent of the amount of superheat of the water. (Dr. of Engg. August Heidrich, in *Die Warme*, vol. 56, no. 6, Feb. 11, 1933, pp. 81–84, 5 figs., *et*)

VARIA

Heat in the House

THIS article deals with the comparative costs of electricity, gas, and coal as sources of heat in the house, particularly in cooking. The answer is not simple, as electricity, more than any alternative methods, has to justify itself by results. One kilowatthour contains only 3413 Btu; if it costs a penny, the customer for the same sum can also buy (but not use) 10,000 Btu of gas (at 10d per therm) or 60,000 Btu of coal (at £2 per ton).

The rapid growth of the domestic electrical load provides proof that the householder is quite satisfied that there is a flaw in the argument somewhere, even if he does concern himself with such academic abstractions (to him) as British thermal units. The flaw lies in ignoring the very much superior utilization efficiency of electricity.

With a view to presenting some information of a fairly definite character, the *Electrical Review* got together from various authoritative sources, including official publications, some figures relating to cooking performances. These show that electric ovens have efficiencies of from 66 to 79 per cent, with an average of 70 per cent; with gas the maximum is 39 and the average 35 per cent. For grilling, one kilowatthour equals 24 cu ft (500 Btu per cu ft) of gas. The percentage efficiencies of electric hot plates vary from 30 to 75.5 as against 32 to 55 with gas. Thus for boiling two pints of water, working tests with electricity have given 58 per cent for the first boil (0.205 kwhr) and 84 per cent for the second boil (0.142 kwhr); gas required 2.36 cu ft and an electric kettle 0.13 kwhr. Both electricity and gas are very much in advance of coal in utilization efficiency; tests on closed cottage and open Yorkshire ranges showed figures ranging from 3.8 to 4.81 per cent. (Editorial entitled "Efficiency or Efficacy?" in *The Electrical Review*, vol. 112, no. 2879, Jan. 27, 1933, p. 109, *c*)

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APPLIED MECHANICS

The Use of Models in Vibration Research. In this paper the theory of dynamic similarity as applied to vibration problems in mechanical engineering is discussed, and a number of specific examples are given. (Paper No. APM-54-14, by J. P. Den Hartog.)

Forced Vibrations With Non-Linear Spring Constants. In many technical applications, couplings are used which have springs in them with an initial set. In this paper an exact theory of the forced vibrations of a system with such a coupling is given. Conclusions concerning the shift in critical speed with the amount of initial set are made. The solution obtained is compared with the existing approximate solution. The more general case of a coupling with stops is solved in an appendix. (Paper No. APM-54-15, by J. P. Den Hartog and S. J. Mikina.)

Design of Columns of Varying Cross-Section. In this paper the author develops formulas for special cases of columns of varying cross-section. The uses of these formulas are illustrated by many problems from practice, and tables of constants for every special case facilitate the application of the theory without going into the solution of differential equations. (Paper No. APM-54-16, by Dr. A. Dinnik [Translated by M. Maletz].)

Compression of Rectangular Blocks, and the Bending of Beams by Non-Linear Distributions of Bending Forces. An existing method for the approximate analysis of two-dimensional stress distributions is extended in scope and applied to two examples of some practical interest. The first is a rectangular plate or block compressed by forces applied centrally to two opposite sides, as by knife edges. Tensions of considerable magnitude are developed across the middle plane through the knife edges. These tensions are determined, and illustrations given of their dependence on the extent of spreading of the load over the bearing area.

The second is intended as a quantitative example of Saint-Venant's principle in the bending of beams. The stresses due to a non-linear distribution of bending forces on the ends are investigated in order to estimate how far from the end one must go to find the linear distribution assumed in the elementary theory of flexure. Conclusions are given in the paper proper, and the mathematical analyses from which they are drawn are presented in appendices. (Paper No. APM-54-17, by J. N. Goodier.)

Thermal Stresses in Spheres and Cylinders Produced by Temperatures Varying With Time. In this paper solutions are given of the problem of stress distribution in spheres and cylinders of elastic material for cases in which the temperature is a function of both the radial coordinate and the time. Two types of temperature variation are included: that due to sudden cooling, as in quenching, and that due to linear surface heating, as in furnace heating. These are applied both to the solid and hollow sphere and cylinder. Examples are included of the temperature and stress distribution in a long solid forging of 30 in. diameter and in a cylindrical drum of 50 in. diameter when each is heated by raising the temperature of its convex surface at a uniform rate. (Paper No. APM-54-18, by C. H. Kent.)

On the Lift Distribution for a Wing of Arbitrary Plan Form in a Circular Wind Tunnel. Previous theories dealing with the interference of wind-tunnel boundaries on airfoil characteristics have in general neglected the distortion of the lift distribution along the span caused by the presence of the boundaries. In the present paper this effect is considered and the general equations for a monoplane wing in a circular wind tunnel, with either closed or open working section, are developed. As an example, the case of an untwisted wing of elliptical plan form is considered in detail, and numerical results are obtained from which curves are plotted giving the more important interference effects. It is found that, at least for this case, the distortion of the lift distribution is rather surprisingly small and has an unimportant influence on the customary interference factors. It is concluded that the simple Prandtl type of correction is satisfactory for all practical cases in which the lack of uniformity of the airstream or the size of the airfoil chord does not become excessive. (Paper No. APM-54-19, by C. B. Millikan.)

Design of Spring Gears for Exhaust-Turbine Installations. The paper outlines the necessity for flexibility in the coupling linkage of a turbine with a reciprocating engine driving the same shaft. A résumé of the history of the problem is given. The conditions which must be fulfilled for satisfactory operation and the details of the calculation to fulfil these conditions are discussed. For simplicity the design chosen relies on propeller damping to hold the torque oscillations within safe limits. Tests with and without flexibility in the turbine gearing are described. It is shown that the problem depends on the vibration characteristics of the system and that a solution can be made if the drawings of the rotating parts and a few engine indicator cards at different speeds are available. (Paper No. APM-54-20, by J. Ormondroyd and T. C. Kuchler.)

Distribution of Pressure Concentrated on a Small Surface. In this paper the author discusses mathematically problems concerning the pressures and deformations that arise when a very rigid die or punch is pressed against a comparatively elastic material, and also in the case where column footings rest on an elastic soil foundation. The author considers (1) the case where the axial section of the die is given and the resulting distribution of pressure along the curved contact surface is required; and (2) where the distribution of pressure over the contact surface is prescribed and the proper curvature of the surface to give such a distribution of pressure is required. Solutions of each of these cases are given for two types of die: namely, when the die is a body of revolution, and when it has a rectangular cross-section the dimension of which perpendicular to the plane of the figure is either very large or very small. (Paper No. APM-54-21, by M. A. Sadowsky.)

The Use of Models in Aerodynamics and Hydrodynamics. In the present paper the author endeavors to present in a simple manner the various laws of similarity and to indicate the ways in which they may be applied to model-testing practice. After explaining the principles of mechanical similarity, he describes different methods of deriving its laws, following which he discusses the functions of Reynolds', Froude's, and Mach's numbers. The closing section of the paper deals with special applications of the laws set forth to fluid

resistance, propellers and fans, cavitation in ship propellers, hydraulic turbines and pumps, flow through pipes and channels, and to fluid problems related to acoustic velocity. (Paper No. APM-54-22, by O. G. Tietjens.)

Air Resistance of High-Speed Trains and Interurban Cars. In this paper a study is made of the economics possible by reducing air resistance of high-speed passenger trains and interurban cars. A critical survey is given of the train-resistance formulas used hitherto and of the various methods of determining the coefficients of these formulas. It is shown that the general ideas on which the train-resistance formulas are based have to be corrected according to the more modern aerodynamic conceptions of air resistance.

Data on the air resistance of train models of various shapes recently obtained in the Westinghouse wind tunnel are given in a number of curves. The methods employed and the experiment set-up are fully described. It is shown that a considerable reduction of air resistance of the present types of trains and interurban cars can be obtained by streamlining.

The fundamental laws of air resistance are stated, and it is shown on what air resistance mainly depends. The importance of the critical Reynolds number is explained, particularly in connection with the reliability of model tests. A striking example is given showing how, by means of streamlining, the air resistance of a body can be reduced to $^1/_{20}$ of its original value. A more rational method of determining the total resistance of trains and interurban cars is given, and it is shown that the streamlining of present-type cars for high-speed service is more justifiable from an economical standpoint than the streamlining of the fuselage of an airplane. (Paper No. APM-54-23, by O. G. Tietjens and K. C. Ripley.)

Vibration During Acceleration Through a Critical Speed. This paper gives an exact solution of the problem of running a system having a single degree of freedom and linear damping through its critical speed from rest at a uniform acceleration. An exact expression is found for the envelope in which are located the maximum amplitudes. The results are plotted for various rates of acceleration and for various dampings. (Paper No. APM-54-24, by Frank M. Lewis.)

The Use of Models in Determining the Strength of Thin-Walled Structures. This paper discusses the status of fundamental theories and explains the circumstances surrounding the use of models to determine the strength of three types of thin-walled structures. The particular types selected represent problems in naval architecture, but their counterparts are frequently encountered in other engineering structures.

Special emphasis is devoted to the necessity for obtaining geometrical similarity between the model and its original and for using identical materials if consistent and reliable data are to be obtained.

The actual methods used in the fabrication of representative models are described in considerable detail, as an aid in their application to other model research. The limits to which riveting and welding can be duplicated are defined, and the use of soldering and spot welding as alternatives is discussed.

In conclusion, the authors point out that the application of intensive thought and study to model research, commensurate with the care devoted to the design of the full-scale structure, is imperative if reliable results are to be expected from the work. (Paper No. APM-54-25, by H. E. Saunders and D. F. Windenburg.)

Stresses in Railroad Track. With the constant tendency in railroad practice to increase the axle loading and the speed of locomotives, the problem of stresses produced in rails by moving loads becomes more and more important. In a study recently made by engineers of the Westinghouse Electric and Manufacturing Company, principally in connection with the study of the tracking characteristics of electric locomotives, there has been developed a method for the experimental determination, not only of vertical but also of lateral forces produced on the rails by a moving locomotive, and it is shown that these lateral forces produce in rails very high stresses. In this paper the authors briefly discuss the theory which has been used as a guide in this experimental research work, and describe some recent experiments in the laboratory and in the field. (Paper No. APM-54-26, by S. Timoshenko and B. F. Langer.)

Resistance of Slender Bodies Moving With Supersonic Velocities, With Special Reference to Projectiles. In this paper the authors apply the hydrodynamical equations for the steady flow of a compressible fluid with axial symmetry to the case of a slightly disturbed parallel flow with velocity higher than the velocity of sound. The linear equation obtained in this way is integrated by a numerical method, and the solution applied to an approximate calculation of the pressure distribution at the head of a projectile. The question of the drag of projectiles is discussed, and the results of the theoretical calculations compared with the values obtained from ballistic experiments. The numerical calculations have been carried out by the junior author, using the methods suggested by the senior author. (Paper No. APM-54-27, by Theodor von Karman and N. B. Moore.)

Strength of Semicircular Plates and Rings Under Uniform External Pressure. The exact solution of the problem of a semicircular ring subjected to uniform pressure involves the solution of a fourth-order partial-differential equation, in conjunction with certain specific foundry conditions. As an exact solution could not be found, the author has developed approximate methods which tests show are sufficiently accurate for practical use in cases where the inner radius of the ring or plate is over 0.4 that of the outer radius. These methods, it is believed, will be found useful by machine designers in the calculation of thrust-bearing plates, split-ring keys, semicircular split diaphragms, and similar mechanical structures. (Paper No. APM-54-28, by A. M. Wahl.)

AERONAUTICAL ENGINEERING

Description and Calibration of 10-Foot Wind Tunnel at California Institute of Technology. The preliminary designs of the 10-ft wind tunnel of the Guggenheim Aeronautics Laboratory at the California Institute of Technology were made in the fall of 1926 under the guidance of Prof. Theodor von Karman and in accordance with his ideas. The detailed design of the tunnel and of most of the auxiliary apparatus were made by the present authors, to a considerable extent in the absence of Dr. von Karman, who later became head of the Aeronautics Department and director of the laboratory. The present paper describes the wind tunnel with its associated apparatus in some detail, and gives the results of the rather elaborate series of calibration tests which have been made up to the present time. (Paper by Clark B. Millikan and Arthur L. Klein.)

Rules for the High- and Low-Angle-of-Attack Loading Conditions. The first half of this paper is a discussion of the recent suggestions of the Department of Commerce regarding changes in the rules for wing loads in the high- and low-angle-of-attack conditions. Several alternative proposals are developed, the chief of which are as follows: (1) Differences in maneuverability should be taken care of by changes in the assumed speed of the airplane instead of changes in the lift coefficient. (2) The assumed speed in the low-angle-of-attack condition should be considerably lower than the terminal diving speed. (3) The loads on the spars should be computed from the design load factor and center-of-pressure location, as at present, instead of by the direct formulas proposed by the Department.

The second half of the paper is a discussion of the rules for loads on fuselages and nacelles in the high- and low-angle-of-attack conditions. Specific changes in the present rules are recommended in order to remove some ambiguities of the present rules, to eliminate the present discrepancy in magnitude between the design loads for the wings and those for the fuselage, and to put the rules for designs with engines in nacelles on a more rational basis. (Paper by Alfred S. Niles.)

Wind-Tunnel Tests on a 1/75 Scale Model of the Goodyear-Zeppelin Airship "Akron" Z.R.S.4 With Normal and Ring Tail Surfaces. An investigation of the aerodynamic characteristics of a 1/75 scale model of the Goodyear-Zeppelin airship "Akron" Z.R.S.4 was made in the closed 10-ft wind tunnel of the Guggenheim Aeronautics Laboratory, California Institute of Technology. The tests were made at speeds up to approximately 77 m per sec, corresponding to a Reynolds number $R = 3.77 \times 10^6$.

In the first part of the investigation, the lift, drag, and moment of

the bare hull and of the hull with normal tail surfaces for various elevator angles were determined, the drag increase by addition of the control car, of the hoods, and of the bumping ball was investigated, and finally the pressure distribution along a symmetrical section of the wake behind the airship was taken.

In the second part, the same hull was tested in connection with various ring tail surfaces, and the pressure distribution in the wake behind the hull determined. From the results it may be concluded that it is possible to obtain a sufficient stability with a ring tail of reasonable dimensions. It is hoped that the ring tail surface may give the possibility of using thicker airship bodies than have been customary in the past, because it decreases the pressure drag of the hull by improving the pressure distribution on the tail.

These tests are of interest because the Reynolds number is relatively high, and because the turbulence of the wind-tunnel airstream is very low as shown by sphere tests. (Paper by Reinhold Seiferth.)

Wind Loads on Airship Hangars. The possibility of failure of an airship hangar owing to inability to resist the forces of windstorms and tornadoes, is a matter worthy of most serious consideration by structural engineers. The author gives a resume of what other investigators have learned, and also recounts wind-tunnel tests which he carried out himself. As a result of a study of these investigations he presents a number of recommendations, and in concluding suggests that American engineering societies should cooperate in accumulating data which will tend to establish a reliable connection between wind-tunnel tests and the actual loads placed on structures in service. (Paper by H. Mact. Sylvester.)

FUELS AND STEAM POWER

Corrosion Tests on Condenser Tubes. This, the fifth report of the A.S.M.E. Special Research Committee on Condenser Tubes, was presented at the Annual Meeting, December, 1931. The results of the Committee's investigations indicate that further comparison of alloys based on actual service hours should bring out some very interesting data on the newer alloys. It appears that the higher-priced alloys may be more economical for installations where the tube life of Admiralty and Muntz metal is short. Data received from marine installations indicate that entrained air is a major source of trouble. Laboratory tests show the extent of the corrosive effect of the presence of entrained air and carbon dioxide in circulating water. It is felt that the control of water velocities and turbulence will greatly reduce tube corrosion. The design of water boxes and other factors that may affect turbulence, and proper drainage of condensers and provision for completely filling all tubes when the condenser is in operation, should be given careful attention.

Some Notes on Performance of Boiler Furnaces. An attempt has been made to determine the actual temperature at the outlet of a boiler furnace from the experimental data available to the author. No claims are made that this method is any more accurate than the Stefan-Boltzmann law, commonly used in calculating furnace temperatures, and perhaps the one explained warrants attention only on account of its simplicity. Initially, the author endeavored to find a relation for a particular boiler furnace between the total heat input to the furnace and the temperature at the furnace outlet, all based upon its overall performance determined by experiment without reference to the Stefan-Boltzmann law. Data on other furnaces were collected to see how closely they followed the same general law. In the discussion of the paper it is pointed out that the results of heat absorption during combustion in the boiler furnace must be consistent with the results for all the others, when expressed in proper units with reference to conditions that prevail. The relations between the variables that are responsible for the result can be made much clearer by a diagram, hitherto not published, and which is based on data from the N.E.L.A. in a statement by the Narragansett Electric Company giving test data on a Babcock & Wilcox boiler with a Combustion Engineering Corporation water wall, arranged for measuring steam produced in the latter. (Paper by A. T. Brown, Mem. A.S.M.E., United Engineers and Constructors, Inc., Newark, N. J., presented at a meeting of the Metropolitan Section, New York, N. Y., March 22, 1932. A copy of the paper, with six drawings, and of the discussion by Prof. Charles E. Lucke, Babcock & Wilcox Company, with **six drawings**, is on file in the Engineering Societies Library.)

Economic Proportioning of Boiler, Economizer, and Air-Heater Surfaces. With larger turbo-generator units and larger boilers capable of operation at high ratings, power-plant investment has continued to decrease, but further decreases are highly desirable. It is unlikely that turbine costs can be greatly reduced. The boiler room therefore offers the greatest opportunities for further reductions in plant cost. Because of the many variables that enter, and the lack of definite knowledge which can be practically applied, the problem of the economic distribution of surface in steam-generator plants has remained to a large extent indeterminate.

The author has attempted to obtain sufficient data to aid in the analysis of the problem, and to correlate and extend existing theories so that these can be applied to determine the economic proportions of boiler, economizer, and air-heater surfaces. His most important new contributions on the subject are: a correlation and analysis of the cost of heat-transfer surfaces as affected by size and pressure, and their presentation on a basis of comparison; an analysis and application of heat-transfer data and formulas to the entire steam generator; a method of ascertaining the temperature and heat content of the flue gas at various places in the steam generator; a method of proportioning steam-generator surfaces; a boiler heat balance; and a justification of high efficiencies on a basis of economy.

As an example of the application of the theory developed to the determination of heat transfer in a boiler, calculations are made for a 750-lb, 650-F power plant having a 100,000-kw output and three generating units, with one boiler for each unit.

In conclusion, the author shows that for the plant considered the most desirable and economical steam-generator efficiency is that which corresponds to an exit flue-gas temperature sufficiently above that which would cause trouble by the formation and deposition of sulphuric acid. This is affected by the sulphur content of the coal, and is 250 deg, corresponding to 87 per cent efficiency for the coal used. (Paper by Warren Viessman, on file at the Engineering Societies Library, New York, where it may be consulted.)

Measurement of Metal Temperatures on Heat-Receiving Side of Heat-Exchanging Apparatus. Modern design of heat-transfer apparatus frequently involves the use of very high metal temperatures. In measuring the temperatures of metal walls under operating conditions, thermocouple wires are attached to the outside wall. The wires are led away through a high-temperature zone

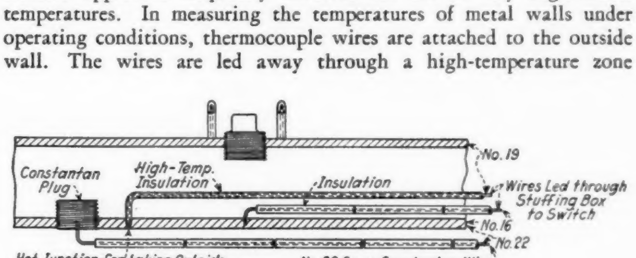

FIG. 1 APPLICATION OF THERMOCOUPLES TO SUPERHEATER TUBE

(for example, hot flue gases), and this tends to make the thermocouple read high, due to the wires being at a higher temperature than the wall, which causes heat to flow from the wires to the junction. In order to determine the magnitude of this error, tests were made under severe operating conditions, the thermocouples being applied to a superheater unit as shown in Fig. 1. The results given in the paper show that with reasonable care in applying the thermocouples

the maximum error will be approximately 2 per cent. (Paper by Arthur Williams.)

OIL AND GAS POWER

Comparative Performance of Diesel and Gasoline Engines in Motor Trucks. In this paper results are given of tests of the comparative performance of Diesel and gasoline engines in motor trucks. The question is raised whether the carburetor is any longer justified, in view of the present high development of the fuel pump. It seems improbable that carburetor engines will ever do any better in running at low speed under load than they are now doing. The possibilities of development of the fuel pump are great. Among these is the application of the Diesel principle to light-oil engines, rendering possible a standard motor-truck engine perfect both from the thermodynamic and the automotive points of view. (Paper No. OGP-54-3, by P. Langer.)

Fuel-Spray Formation. Experiments are described in which the diameters of the fuel drops in sprays from different types of nozzles were measured and the effects of fuel-injection pressure, nozzle dimensions, and the density of the chamber air on the atomization of the sprays were determined. A simple method of determining the size and form of the high-velocity parts of sprays is also described. High-speed spark photographs of fuel sprays are shown that were made with lens systems having magnifying powers of 0.5, 2.5, and 10. These photographs reveal the process by which the fuel is transformed from the solid jet to the atomized spray, and also show the effect of several factors on spray dispersion. (Paper No. OGP-54-4, by D. W. Lee.)

A Proposed Speed Characteristic for Oil Engines. The author proposes a method of readily classifying oil engines as low, medium, high, or super-high speed, by means of a "speed characteristic" equal to the square of the revolutions per second multiplied by twice the stroke in feet. To show that the method provides a consistent and practical means of classifying engines, he applies it to the data of some 84 modern engines covering a wide range of sizes, speeds, and powers. (Paper No. OGP-54-5, by V. L. Maleev.)

PETROLEUM MECHANICAL ENGINEERING

Effect of Vacuum on Lubricating-Oil Distillation. Vacuum distillation of lubricating oils possesses many advantages, and the paper brings out some of its basic features. The benefits of the vacuum process are mainly in the reduction of cracking, in the improved separation of fractions, and the reduction of heat input and condensing requirements. The author mentions a possible fractionator design and suggests a condenser design. (Paper No. PME-54-6, by R. S. Danforth.)

Analysis of Stresses in Sucker-Rod Joints. A recent analysis of oil-field pumping production showed that 25 per cent of the lost production was caused by sucker-rod troubles. Much research has been attempted to determine the loads carried by the rods, but heretofore no attention has been given to the stress condition existing in the sucker-rod joint. These joint failures amount to 72 per cent of sucker-rod failures. As the sucker-rod joint is the largest individual trouble maker in pumping operations, the purpose of the paper is to determine the magnitude and distribution of load in the joint and to discuss methods of studying the problem. (Paper No. PME-54-7, by Emory Kemler.)

Properties of Hydrocarbon Mixtures at High Pressures. The paper provides a comparatively simple method for the design of apparatus handling complex hydrocarbon mixtures at extraordinary pressures. The computation methods outlined enable one to calculate the density of any vapor, mixed or otherwise, at any temperature and pressure; the heat effect of any heating or cooling operation, whether conducted at constant pressure or changing pressure; the equilibrium between vapor and liquid at any temperature and pressure; the equilibria and changes in concentration throughout the tower in any operation of rectification or absorption, at whatever pressures they may be conducted; and the isothermal reversible work of compression of vapor mixtures, whatever the pressure range. These computation methods enable the refining engineer to design high-pressure equipment and operations with a high degree of precision. (Paper No. PME-54-8, by W. K. Lewis and C. D. Luke.)

Design Considerations of a Natural-Gas Transmission System. Since design is one of the chief factors in the economic success of a transmission system, the engineering principles and the requisite empirical data are discussed herein as employed in the design of a pipe-line system now completed. The maximum day demand in successive years of development is analyzed by component parts, particular emphasis in the domestic element of the load being given to previous usage of manufactured gas in terms of Btu per average meter for range and water-heating purposes and to the probable space-heating element based upon the degree-day deficiency method. A brief discussion is included for basic relationships of the factors in the pipe-line flow formula. Consideration is given to relative physical advantages to be derived from application of an understanding of compressor requirements at varying ratios of pipe-line pressure expansion. The unusual features inherent in the looping of lines are shown graphically. Reasons for using a 24-hour instead of a 1-hour period as the time interval of maximum load in design are explained. A diagrammatic presentation of a part of an actual system is made, and discussion thereof is included, to illustrate the manner in which the several engineering principles apply. (Paper No. PME-54-9, by Charles W. Merriam.)

Modern Oil-Lubrication Methods as Applied to Rolling-Mill Equipment. The paper traces the improvement made in lubricant-application methods for rolling-mill machinery from earlier days to the present. The increase in size, speed, and capacity of rolling-mill machinery necessitated the use of heavier oils and of better methods of application. The modern heavy-oil circulating system is described, and common practice in the selection of oils for various types of equipment is indicated. Modern oil conditioning and application give maximum safety and protection against involuntary shutdowns and cut costs of lubrication as much as 80 per cent. (Paper No. PME-54-10, by J. A. Merrill and E. M. May.)

RESEARCH

What Can Be Accomplished With Modern Machine Tools and Cemented Carbide Cutting Tools. Possibilities of the cemented carbides were determined on a lathe built for the General Electric Company. Results of the manufacturer's tests are given, with information on tools used and type and amount of chips produced. Some results obtained with cemented carbide tools on two standard types of lathes are presented. A description of a new roll-turning lathe follows, with examples of its work. Cemented carbide tools are treated in a general way, and conclusions are drawn as to what may be accomplished by the substitution for obsolete equipment in machine shops of machines capable of using tungsten carbide and tantalum carbide tools. (Paper by A. A. Merry.)

Fatigue Tests of Helical Springs, and Number of Inactive Coils in Compression. This is Progress Report No. 1 of the Subcommittee on Heavy Helical Springs of the A.S.M.E. Special Research Committee on Mechanical Springs. It describes the formulation of the program for fatigue tests of helical springs, and announces results from the preliminary runs. These results are as yet too meager for detailed discussion, which is therefore postponed until a later report. A subsidiary but very important problem, the number of dead or inactive coils in a helical compression spring, is taken up; a special analysis is proposed for the development of this number from data taken in connection with the fatigue tests; and some special tests supporting the accuracy of the results of this analysis are described in detail. (Paper by C. T. Edgerton.)

Peroxide Bleaching of Textiles. Since 1927 the concentrated electrolytic hydrogen peroxides have almost completely replaced all other peroxides in textile bleacheries. The paper includes a classification of peroxide bleaching; peroxide bleaching of wool, silk, rayon, and cotton. (Paper by H. G. Smolens.)

CORRESPONDENCE

READERS are asked to make the fullest use of this department of "Mechanical Engineering." Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Credit Control Vs. Overinvestment

To the Editor:

The suggestion of Dr. Dickinson in the February issue of Mechanical Engineering that engineers and economists agree on a workable plan for improving the economic situation is a particularly pertinent one.

The gravest problems which confront us all today are unemployment and credit contraction, and engineers are probably in closer touch with the first of these than any other group of men. In fact, many hold the engineering profession responsible in great measure for the existence of unemployment.

The answer to unemployment is work. And the only way enough work can be provided is by shorter hours in industry. If agreement can be reached in this, it will not be difficult to agree on ways and means. A standard week of forty hours with double time for overtime, if applied widely in industry, would do much to solve the unemployment situation without placing an excessive burden on industry.

The problems of credit and banking are a little beyond the realm of engineering, but engineers could safely advocate stricter supervision of banks, particularly in the matter of granting charters. There has probably been an overproduction of banks, to the detriment of sound finance.

R. M. Garrison.[1]

Houston, Tex.

Coordinate Planning

To the Editor:

In his article entitled "Coordinate Planning," in the February issue of Mechanical Engineering, Mr. Heermance makes a strong case for trade-association control. The weakness of trade-association control from the social or consumer standpoint is evident from the statements that "Under an industry budget system, each company knows the total consumption which can be expected, and the capacity required by the trade to carry the load. . . . The company knows approximately its own share of that consumption and equipment. . . . Planning for the industry makes individual budgeting more accurate. . . . Competition tends to become a race to improve efficiency and service, to reduce costs to lower prices and thus increase volume." The last statement is fine, but is not a logical conclusion from the preceding statements. If each company knows and is guided by its share of the requirements, how can it go after the other fellow's share? It is only too evident that the whole set-up is designed to establish monopolies and avoid competition.

This also is interesting: "Another need was a definite policy in the disposal of obsolete machinery, to keep it from coming back into competition by the second-hand route." Why need a company with efficient machines and satisfied to sell at a fair price, fear competition from a company with inefficient machines? The only social excuse for installing new machines is to be able to produce and sell goods at a lower price than was possible with the old machines.

J. E. Webster.[2]

East Pittsburgh, Pa.

To the Editor:

If we analyze almost any industry, we find two types of competition. Certain companies, by reason of their efficiency, are able to reduce their costs, lower prices, and gradually gain a relatively larger share of the business without sacrificing their profit. Sound management tries to avoid production at a loss. Other companies, through ignorance or desperation, slash prices without regard to cost, and disrupt the market, with no profit to themselves. In this case there is no permanent benefit to the public, because the low price to the consumer has been gained at the expense of the producer. Industry budgeting tends to emphasize the first type of competition rather than the second. No monopoly is contemplated, nor is such a thing possible under the present competitive system.

Second-hand machinery, though usually less efficient, is obtained at a sufficiently low capital cost to enable a manufacturer to keep on producing, even if he does not make much, if any, money. By encouraging the ignorant type of competitor to stay in the market, it demoralizes the price level, both directly and by increasing the overcapacity in the industry. In the knitted outerwear industry, to which I referred, it was felt that junking obsolete machinery and thus keeping it out of competition would help to reduce the serious surplus of productive equipment, which is an expensive matter for the producer and in the long run for the public.

Edgar L. Heermance.

New Haven, Conn.

V.D.I. English-Speaking Circle in Berlin

To the Editor:

The writer had the privilege, on January 5 of this year, of attending the second meeting of the English-Speaking Circle of the Verein deutscher Ingenieure in Berlin. Professor S. J. Davies, of London, lectured on the subject, "High-Speed Heavy-Oil Engines, Their Characteristics and Tendencies of Their Development."

The club was organized last fall and will meet once a month. It now has one hundred and fifty members. At each of its meetings a lecture in English is given by some engineer from

[1] Research Engineer, J. H. McEvoy & Co. Jun. A.S.M.E.

[2] General Works Engineer, Westinghouse Elec. & Mfg. Co. Mem. A.S.M.E.

an English-speaking nation, followed by a public discussion which, of course, is conducted in English. Each meeting is followed by a dinner, at which only English is spoken. Most of the membership of the circle is composed of German engineers. The club is supported by the V.D.I., The American Society of Mechanical Engineers, and the (British) Institution of Mechanical Engineers. A similar circle of German-speaking engineers was organized in London about two years ago under the direction of the Institution of Mechanical Engineers.

At the dinner which followed the January 5 meeting there was an informal and entirely impromptu round-table discussion which is worthy of mention. Dr. Conrad Matschoss, Director of the Verein deutscher Ingenieure, proposed to the group that opinions regarding the new and rather indefinite subject of "Technocracy" be presented. After some explanation of the meaning of the term and purpose of the new movement, it was decided that while technocracy as a cult may not solve our difficulties, the world will probably be helped out of its present plight by an increased application of technical knowledge and improvements.

The writer had not previously had the experience of listening to a round-table discussion by engineers of several nations who were so earnestly endeavoring to clarify their minds as to a solution of a common international problem. That a discussion of such interest and value should take place at a gathering where a foreign language was being spoken is truly noteworthy. Certainly such groups as the Verein deutscher Ingenieure's English-Speaking Circle will prove to be powerful agents in increasing international friendship and cooperation.

HERBERT H. WHEATON.[3]

Berlin, Germany.

The Economic Characteristics of the Manufacturing Industries

TO THE EDITOR:

In his paper on cost analysis in the November, 1932, issue of MECHANICAL ENGINEERING (p. 759), Professor Rautenstrauch has plotted Willans lines for manufacturing costs, and, like orthodox Willans lines, they are pretty straight. Some of the ramifying consequences of what may be called the Willans law in the field of costs have been recognized for a long time, but this seems to be the first comprehensive presentation.

Of particular interest are his remarks on dumping. Dumping is a special case of what the economists describe as "class pricing." It is shown in the paper that where 60 per cent of the output is sold at a \$10 unit price against an \$8.80 unit cost, it is highly profitable to the producer to sell an additional 40 per cent of output at a \$5.50 price, even though the unit cost on the whole product then stands at \$6. Certain representatives of the public are exceedingly resentful of class pricing, particularly as practiced by public utilities. They regard it as a downright injustice to the class which pays the higher price. The factors in Professor Rautenstrauch's paper permit reducing the argument to an arithmetical basis.

If 600 units are sold for \$10 against a cost of \$8.80, the total profit is \$720. Suppose it is now possible to "dump" 400 more units at the \$5.50 price. The total product will be 1000 units and the total cost \$6000. The revenue from 400 units sold at \$5.50 each is \$2200. The break-even point involves a revenue, then, of \$3800 from the old customers, that is, on the 600 units which they take.

If \$720 profit is added to this the total necessary revenue from these 600 units is \$4520, or the price to be paid by the old customers who purchase these units is \$7.53 each.

This assumes a constant total profit on the fixed property, which seems the proper assumption. If, however, the producer insists on a constant ratio of profit to sales, then the price of the 600 units sold to the old customers would be \$8.33 each.

To sum up, the buyers of the original 600 units were paying \$10. As a result of "dumping" 400 additional units at the absurdly low price of \$5.50, the buyers of the original 600 units are not harmed. On the contrary, they are helped, because the unit price which they pay is reduced from \$10 to \$7.53 or \$8.33, as the case may be.

If they insist that all customers shall be treated alike, then the price to all customers will be \$6 plus profit, per unit. By hypothesis, "dumping" will then be impossible. The remaining question at issue is the extent to which a reduction of unit cost from \$8.80 to \$6 could expand sales above 600 units. Possibly in many cases this question is not thoroughly examined by those embarking on a "dumping" program.

Highly important points are the slope and vertical position of the total-cost curve. These are suggested by a ratio called the "capital turnover," defined as the ratio of annual sales to total investment. Constant total costs are in general largely determined by the investment. This is true in the main of property taxes, interest, insurance, and depreciation. If the capital turnover is high, the investment is low in relation to annual sales. Constant total costs are also apt to be low and the Willans line high and steep.

Where the capital turnover is high, variable total costs are important and good management is largely a matter of control of materials and labor. This is the situation which is found in average manufacturing, where values of capital turnover range up to 3.0 or more. They are high in manufactures of food and kindred products; particularly, for example, in slaughtering and meat packing. Still higher values are found in certain merchandising enterprises.

With low values of the capital turnover, the constant total costs are important and the influence of the load factor (more strictly, use factor) is very great. It is in such industries that there are encountered the problems involved in "dumping" and in class pricing generally. The generation of electric power and the conduct of railroad transportation are both enterprises of low capital turnover. (So also, it happens, is farming.) Minimum possible values of capital turnover are those at which the fraction expresses the ratio of constant total costs to total investment. Possibly the nearest approximations found to this situation are in certain publicly owned power-generating projects where the capital turnover may be in the neighborhood of 0.10 or even slightly lower.

WILLIAM D. ENNIS.[4]

Hoboken, N. J.

TO THE EDITOR:

Professor Rautenstrauch's paper is a timely addition to the problem of economic plant management. Perhaps the most important contribution which he makes is the stress which he lays on graphical analysis of the elements of the manufacturing enterprise, and his paper should serve well as a preliminary step toward the realization of more rigid analyses by mathematical economics and by the application of statistical methods to determine the actual lines or curves instead of the approximate ones which he submits.

[3] Freeman Traveling Scholar of the American Society of Civil Engineers.

[4] Alexander Crombie Humphreys Professor of Economics of Engineering, Stevens Institute of Technology. Mem. A.S.M.E.

Many of the problems which are analyzed in some detail in the paper are familiar ones in other industries, and perhaps the methods used in another field may be of interest. In the public-utility field, for example, the so-called "problem of dumping" is a familiar one and its basic essentials are well understood. Adopting Professor Rautenstrauch's nomenclature, the expense equation, $Y_1 = a + bx$, is the familiar marginal-cost equation—variously called incremental or differential-cost equation. The determination of the break-even point is, of course, very simple. Using the general form for a constant unit price, the revenue may be represented by $Y = cx;$ then naturally x, the break-even capacity, is that capacity where the revenue equals the cost or where $Y = Y_1$, hence $cx = a + bx$ and $x = a/(c - b)$. In other words the break-even point is at that capacity equal to the fixed or constant total cost divided by the difference of the slopes of the two lines.

The apparent paradox of the dumping problem may be completely avoided by considering the nature of the cost curve and its relation to the revenue curve. As we pass from zero capacity to the break-even point there is a gradual reduction in the loss per unit of output, and from that point to maximum capacity, a gradual increase. This is perhaps best seen from the unit-cost and revenue curves. As long as the ordinates are measured up from the revenue curve there is a unit loss, while if they are measured down from the revenue to the cost curve there is a unit profit. Very obviously as long as the former is a horizontal line and the latter a hyperbola, the unit profit will be an increasing function which can very simply be written as

$$p = (c - b) - \frac{a}{x}$$

and the total net profit will be

$$px = P = (c - b)x - a$$

With any assumed value of P greater than zero, then if b and a are constants as they are assumed to be, c must decrease if x increases, thus permitting additional units of output to be taken on at values of c_1 which will be less than c. In fact, having reached a given value of P sufficiently large, additional units of output may be taken on at any price in excess of the unit marginal cost as given by b in the cost equation. The effect of this will be to increase the net profit and decrease the unit cost of production. This is the policy generally followed by public utilities in selling large blocks of power.

In fact, in many cases additional blocks may be taken on at a unit revenue even less than this b, because often the expense is not a simple straight line but rather a parabola which flattens out as the output increases. This is the case where the manufacturing industry turns out a single product by means of a process whose technical efficiency is increased by an increased load factor and in consequence the true unit-cost curve is not the simple hyperbola previously mentioned but a more complicated one whose curvature is such that it may fall below the other. This point is one of great importance, but is beyond the scope of a discussion such as this.

In Fig. 2 of his paper Professor Rautenstrauch presents a yeast problem, and it will perhaps be of interest to apply the simplest statistical methods to this particular problem and see what difference exists between the approximate curves that are there presented and those which statistical methods will yield, and thus the usefulness both of this approximate graphical presentation and the more rigorous mathematical treatment will be shown. The data for Fig. 2, kindly furnished me by the author, are given in the accompanying table.

	Output in pounds	Cost
January	900,000	$160,800
February	825,500	152,000
March	870,000	154,500
April	840,000	158,000
May	922,000	165,500
June	855,000	156,000
July	897,000	162,000
August	905,000	167,000
September	925,000	165,000
October	1,010,000	172,000
November	940,000	168,000
December	1,043,000	175,000
	10,932,500	$1,955,800
Average	911,200	162,800

The "least squares" method of curve fitting used in statistics (see "Control of Operating Expenses," MECHANICAL ENGINEERING, October, 1932, p. 732) yields the following equation:

$$\text{Operating Cost} = Y_1 = \$68,432 + (\$0.104 \times \text{lb of yeast})$$

In a similar manner the curve for revenue is

$$\text{Revenue } Y = \$0.205 \times \text{lb of yeast sold}$$

The break-even point will then be, in pounds of yeast,

$$x = \frac{68,432}{0.205 - 0.104} = 676,000$$

or slightly lower than the 725,000 lb approx. from Fig. 2. This difference is caused by the fact that the equation of the curve presented in Fig. 2 is

$$Y_1 = \$98,214 + (\$0.0714 \times \text{lb of yeast})$$

instead of the correct figure given above.

The derivations of the economic laws which are given in this paper are of great interest, but more general laws can be adopted from any of the standard works on mathematical economics; and it is to be hoped that the methods of analysis presented in the paper will be widely adopted, for they will do much to help many manufacturing enterprises to escape from the troubles they are now in.

R. T. LIVINGSTON.[5]

New York, N. Y.

TO THE EDITOR:

About ten years ago while investigating a small business for manufacture of boxes the writer worked out curves for the break-even point as shown in Fig. 1 of Professor Rautenstrauch's paper. Later in connection with costs and selling-price estimates for a cotton mill he developed modifications of this chart to suit the continuous processes of such a mill. The market price of the material in the form of cotton or of yarn may fluctuate from day to day, or the material cost used in estimating may require change for various reasons. Also the selling price of the product, and therefore total income, must vary with the market. It therefore becomes necessary to show these variations in the curves in some way.

The first form which was used was a curve of the form of Fig. 8 of the paper in question, in which, however, all the items of cost, except material, were expressed by lines below the material cost, and the line wxz was expressed by a plurality of lines plotting the material cost at different unit prices above the total of costs exclusive of the material. Correspondingly a plurality of lines like the line oxs were drawn for different

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selling prices for the product. The numerous intersections proved to be tedious to discern, although it was easily possible to interpolate for the break-even point at an intervening material cost or selling price.

In order suitably to present the situation for different conditions of the raw-material and the product markets, advantage was taken of the "bogey" or standard costs which were in use. By determining the total-cost curve, excluding material but including waste, all figures being taken at bogey, a single line was plotted which could be intersected by a plurality of lines related to selling price and reflecting income. These income lines expressed not the total money representing value of product, but rather the differential above the bogey cost of the raw material, i.e., cotton or yarn. They represented the operating income at certain differentials. Thus, the break-even point determined the volume of business necessary at a given differential to meet operating cost and without being affected by variations from the bogey or standard operating conditions, these being reflected in actual costs, and without being vitiated by the effect of merchandising loss or gain. The latter has nothing to do with operating loss or gain, and should be expressed in a set of curves of different character.

The writer wishes to emphasize also the value of coordinating the break-even chart with the unit-costs chart for determining whether or not to take business at a given price. The unit-costs chart alone is not sufficient. However, it readily reflects the range of production through which marked gain can be made by increase of production and the range through which it requires too large an increase with the attendant necessity for larger working capital and other disproportionate expenditure and effort in order to break even or to obtain a profit. The unit-cost curves shown in the paper are not good illustrations of this feature because they are not extended far enough to the right, that is, to the low-cost region, to acquire a flat slope. For example, in that region in the cotton mill in question an increase from the production of one shift to one and a half shifts indicated for one process a difference of 1 cent per pound, which frequently at the time mentioned meant the difference between getting business and not getting it. However, to run two shifts, that is, double production, less than half a cent further reduction in cost was obtained. Among other disadvantages, to have run two shifts would have meant doubling the operating force in the mill and large raw-material inventory.

While in practice the lines will not be simple straight lines, nevertheless the representation graphically of the relations discussed is believed to be of great value in determining policies relating to sales, quotations, and marketing as well as budgeting, if the curves are laid out to suit the conditions of the business and are properly interpreted.

ALFRED F. ERNST.[6]

New York, N. Y.

TO THE EDITOR:

In determining "conversion" costs and production costs great care should be taken in respect to the overhead expense. In one case the entire overhead or burden may be considered irrespective of the volume of physical output. In such a case the curves on the cost chart will be different from curves plotted where only that portion of overhead is considered as a part of the cost of product which is actually incurred in manufacturing the product.

In other words, if a $5,000,000 plant has a productive capacity of 10 million units, each unit will be charged with 1 cent overhead if operated at full capacity and 2 cents if operated at half-capacity. The correct overhead will be always 1 cent per unit, but if only half of the plant is productively engaged, then the $500,000 is an idle overhead and constitutes a loss of the concern, not an added cost of the product it did not produce.

WALTER N. POLAKOV.[7]

New York, N. Y.

[6] Associate, Newell & Spencer, Patent Attorneys. Mem. A.S.M.E.

[7] Walter N. Polakov & Co., Inc.

Engineers Must Service Their Technology

TO THE EDITOR:

Engineers are being blamed quite generally for the depression, the effects of which every one is feeling these days. The public is in the same frame of mind regarding technological advances in production that a small boy might be toward a Christmas jackknife which had cut his fingers badly. Whittling instructions are as essential to effective generosity as a keen blade, for a knife that cuts fingers is certainly worse than no knife at all. Just as the donor of the knife cannot avoid accusing eyes, so the engineer cannot escape condemnation.

Engineers seem to have spent too much time in the past in merely sharpening the tools of industry, and too little effort in giving instructions in the economic use of the processes of production. We have given so little thought to ultimate social utility that most of us do not even know how the clever methods and machines we have devised ought to be handled. Yet when they go wrong, engineers are blamed.

Certainly, as the cycles of production have lengthened, the time required for readjustment has been greatly increased. It takes years to get activity into full swing through mine, mill, forest, factory after factory, wholesaler, and retailer, and it takes years to slow down once that state has been reached. Meanwhile men grow old and come upon suffering. The technology of production, when unskilfully handled, becomes a technocracy of destruction.

Stabilization has been proposed to keep the huge, though efficient, production machine running steadily in order to avoid disaster. Society would lock the governor, or at least introduce friction, to oppose change. We have been trying to stabilize wage rates, to fix prices, and even to maintain governmental expenditures. Consumption, however, has all the variation of any other demand load. The ultimate personal wants to be satisfied change from day to day and from year to year, with all the fads and fancies of a hundred million individuals.

We might, of course, go to the very root of the matter, and try to do away with all personal preferences, but our nation is not prepared to preordain the lives of each of us from birth to death. Even in Russia, dictatorship has had to yield to personal choice, with piece-rate pay and certain "voluntary" plans. Moreover, with our present knowledge we cannot hope to control the more important chances which nature shuffles for us. We cannot stabilize our wants.

We have tried to stabilize with a flywheel of overproduction, but the work put into it could never be fully recovered. Even if people's desires did repeat during the upswings of the so-called business cycle, no one would accept old goods at full price. No one would buy a three-, or a five-, or a seven-year-old automobile even if it had never been used, or would relish three-, five-, or seven-year-old eggs, butter, or meat, no matter how well stored. The accumulator method of stabilization has not worked.

The results of attempted stabilization have been just what

an engineer would expect of a sticking governor with a varying load: "institutional frictions in a changing world," in the words of the economist Alvin Hansen. The technological machine "hunts." Adjustments do not take place until they are catastrophic. The more engineers build up the production machine and add to its inertia, the longer and more violent will the swings become under stabilization. An engineer would know that a highly organized society needs to be more, and not less, responsive to changing conditions. It must adjust quickly, while small changes will suffice, and not resist to the bitter end with stabilization.

Engineers must prepare and publish instructions for using the production system they have created, or they can expect to be cursed by the public. Engineers will not be allowed to continue to sharpen knives that cut people. They will not be allowed to go on applying technology if it operates dangerously. MECHANICAL ENGINEERING is helping us to become conscious of our neglected duty. We must put on the overalls, and service technology right out in the social field.

KNOX A. POWELL.[8]

Minneapolis, Minn.

A.S.M.E. Boiler Code

Revisions and Addenda to the Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place in the Code.

The following proposed revisions have been approved for publication as addenda to the Code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticism and approval from any one interested therein. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

EXEMPTION CLAUSES PRECEDING LOCOMOTIVE BOILER AND UNFIRED PRESSURE VESSEL SECTIONS:

Omit the words "inspection and/or."

PAR. P-288*b*. REVISED:

b Every independently fired superheater which may be shut off from the boiler and permit the superheater to become a fired pressure vessel shall have one or more safety valves having a discharge capacity EQUAL TO 6 LB OF STEAM PER SQ FT OF SUPERHEATER SURFACE MEASURED ON THE SIDE EXPOSED TO THE HOT GASES. THE NUMBER OF SAFETY VALVES INSTALLED SHALL BE SUCH THAT THE TOTAL CAPACITY IS AT LEAST EQUAL TO THAT REQUIRED. [based on Par. P-270. If communication between the superheater and the boiler cannot be closed, safety valves shall be provided as prescribed in Par. P-288*a*.]

PARS. H-46 AND H-99. MODIFY PROPOSED REVISION PUBLISHED IN JANUARY ISSUE TO READ:

H-46 (H-99). Safety valves shall be connected to boilers with THE spindle vertical if possible, directly to a TAPPED OR FLANGED OPENING [tapping] in the boiler; [or by two close nipples and] TO a tee CONNECTED TO THE BOILER BY A CLOSE NIPPLE, TO WHICH MAY BE ATTACHED [for a surface blow connection or for a water column top connection; or to] a Y-base twin valve connection; [or] to a valveless steam equalizing pipe between adjacent boilers; or to a valveless header connecting steam outlets on the same boiler. A SAFETY VALVE SHALL NOT BE CONNECTED TO AN INTERNAL PIPE IN THE BOILER.

[8] Assoc-Mem. A.S.M.E.

PARS. H-64*a* AND H-117*a*. REVISED:

H-64 (H-117). *Low-Water Fuel [Supply] Cut-Off. a* It is recommended that EACH [on all] automatically fired steam AND [or] vapor HEATING [system] boiler[s] BE PROVIDED WITH a low-water fuel [supply] cut-off OF DEPENDABLE CONSTRUCTION. IF USED, ANY SUCH DEVICE SHALL be [installed in such location] SO LOCATED that [it automatically shuts off] the fuel supply WILL BE AUTOMATICALLY STOPPED when the LEVEL [surface] of the water IN THE BOILER REACHES [falls to] the lowest safe water line. THIS POINT SHOULD NOT BE LOWER THAN THE BOTTOM OF THE WATER GLASS.

ANY SUCH DEVICE WHEN USED SHALL BE ATTACHED TO THE BOILER OR TO THE RETURN LINE TO THE BOILER BY AT LEAST 1 IN. PIPE CONNECTIONS. DESIGNS EMBODYING A FLOAT AND FLOAT BOWL SHALL HAVE A VALVED DRAIN BY WHICH THE BOWL CAN BE FLUSHED AND THE DEVICE TESTED.

PAR. U-17. REVISED:

U-17. For all pressure vessels, the minimum thicknesses of shell plates, heads, OR [and] dome plates, after flanging, shall be $^1/_8$ IN. EXCEPT THAT FOR RIVETED CONSTRUCTION THE MINIMUM THICKNESS SHALL BE $^3/_{16}$ IN. VESSELS WHICH ARE OF A SIZE THAT WILL NOT HOLD THE SHAPE WITHOUT ADDITIONAL SUPPORT MUST BE PROVIDED WITH STIFFENERS SO DESIGNED AS TO PREVENT DISTORTION DUE TO THEIR OWN WEIGHT AND/OR TO INFLUENCES CAUSING STRESSES OTHER THAN THOSE DUE TO INTERNAL PRESSURE. [as follows:]

[When the Diameter of Shell is	In.
16 in. and under	$^1/_8$[1]
Over 16 in. to 24 in.	$^3/_{16}$
Over 24 in. to 42 in.	$^1/_4$
Over 42 in. to 60 in.	$^5/_{16}$
Over 60 in.	$^3/_8$

[1] For riveted construction the minimum thickness shall be $^3/_{16}$ in.]

PAR. U-59*b*. ADD FOLLOWING SENTENCE AT END OF LAST SECTION OF PAR. U-59*b*(1):

IF THE DIFFERENCE BETWEEN THICKNESS *t* AND ACTUAL THICKNESS *m* REPRESENTS MATERIAL ADDED FOR CORROSION, THE REINFORCEMENT MUST BE COMPUTED ON THE BASIS OF THICKNESS *t* AND NO CREDIT TAKEN FOR THE CORROSION ALLOWANCE.

UNDER "RIVETED CONNECTIONS," REVISE FIRST SECTION TO READ:

Materials for riveted openings shall be of rolled, forged, or cast steel, OR CAST IRON AS HEREIN PROVIDED.

UNDER "RIVETED CONNECTIONS," INSERT THE FOLLOWING AS THE SECOND SECTION:

CAST IRON NOZZLES AND FITTINGS MAY BE USED IF THE PRESSURE DOES NOT EXCEED 160 LB PER SQ IN. AND/OR THE TEMPERATURE DOES NOT EXCEED 450 DEG FAHR. RIVETED CAST IRON FITTINGS MAY BE CONSIDERED AS REINFORCEMENT AS PERMITTED BY THIS PARAGRAPH PROVIDED THE THICKNESSES OF THE CAST IRON PARTS

ARE NOT LESS THAN $^5/_8$ IN. AND THAT THE TOTAL AREA OF THE CAST IRON REINFORCEMENT IS AT LEAST TWICE THAT REQUIRED FOR STEEL.

PAR. U-64. MODIFY PROPOSED REVISION PUBLISHED IN MARCH ISSUE TO READ:

U-64. *Hydrostatic Test.* Each vessel constructed under these rules shall be tested under hydrostatic pressure to not less than $1^1/_2$ times the maximum allowable working pressure EXCEPT AS REQUIRED FOR [For vessels of] fusion-welded VESSELS BY [construction the requirements of] Par. U-77 [shall apply. Exceptions:] AND EXCEPT AS REQUIRED for enameled vessels FOR WHICH the test pressure SHALL BE AT LEAST BUT need not exceed the working pressure.

[For] Gas-storage vessels which are so BUILT OR INSTALLED AS NOT TO BE ABLE [too large] to withstand safely the weight of the large mass of water required to fill them for hydrostatic test [they] may be tested by compressed air at a pressure OF AT LEAST, BUT WHICH NEED not [to] exceed the maximum allowable working pressure of the vessel, PROVIDED THE ALLOWABLE WORKING PRESSURE DOES NOT EXCEED 80 PER CENT OF WHAT WOULD BE PERMITTED IF SUBJECTED TO THE PRESCRIBED HYDROSTATIC TEST.

PARS. U-69*a* AND U-70*a*. INSERT THE FOLLOWING AS SECOND SENTENCE OF SECOND SECTION:

EXCEPTION TO THIS IS ALLOWABLE WHEN THE WELDER IS REGULARLY EMPLOYED ON PRODUCTION WORK EMBRACING THE SAME PROCESS AND TYPE OF WELDING, IN WHICH CASE THE TESTS MAY BE EFFECTIVE FOR A PERIOD OF ONE YEAR.

PARS. U-71 AND P-103. REVISE SECOND SENTENCE OF FIRST SECTION TO READ:

Shells fabricated from pipe OR TUBING shall conform to Specifications S-18 for Welded and Seamless Steel Pipe OR S-17 FOR LAP-WELDED AND SEAMLESS STEEL AND LAP-WELDED IRON BOILER TUBES.

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretation of the Committee in Cases Nos. 727 (reopened), 749 (reopened), and 751 to 755, inclusive, as formulated at the meeting of March 24, 1933, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE No. 749 (Reopened)

Inquiry: Do not the provisions of Par. U-77 of the Code, which require hydrostatic testing of all welded pressure vessels, conflict with those of Par. U-64, which provide for testing by air pressure if the size is too great for the foundations to withstand the weight of the water used in testing?

Reply: It was the intent in the revision of Par. U-64 to make an exception of large fusion-welded vessels for gas-storage purposes. To provide for this it is proposed to revise Par. U-64 as follows:

U-64. *Hydrostatic Test.* Each vessel constructed under these rules shall be tested under hydrostatic pressure of not less than $1^1/_2$ times the maximum allowable working pressure except as required for fusion-welded vessels by Par. U-77, and except as required for enameled vessels for which the test pressure shall be at least but need not exceed the working pressure.

Gas-storage vessels which are so built or installed as not to be able to withstand safely the weight of the large mass of water required to fill them for hydrostatic test may be tested by compressed air at a pressure of at least, but which need not exceed, the maximum allowable working pressure of the vessel, provided the allowable working pressure does not exceed 80 per cent of what would be permitted if subjected to the prescribed hydrostatic test.

CASE No. 751 (In the hands of the Committee)

CASE No. 752

Inquiry: May a vessel of any shape be exempted from the requirements of the Code for Unfired Pressure Vessels if either of the formulas in Par. U-1 make such compliance with the Code unnecessary?

Reply: It is the opinion of the Committee that the requirements of the Code for Unfired Pressure Vessels need not apply to any vessel which is exempted by either of the formulas in Par. U-1.

CASE No. 753

Inquiry: Do attachments on Class 1 or Class 2 unfired pressure vessels which are not pressure-resisting parts necessarily have to be stress relieved where that procedure is otherwise required?

Reply: It is the opinion of the Committee that all heavy attachments, such as supporting lugs, which are welded on to Class 1 or Class 2 unfired pressure vessels, should be stress relieved. Attachments the failure of which would not affect the safety of the vessel, need not be stress relieved, provided the requirements of Par. P-186 of the Power Boiler Section of the Code for the tack welding of non-pressure parts are complied with.

CASE No. 754

Inquiry: When there are several vessels of identical dimensions and of the same grade of material being welded, will it be permissible under Par. P-102*b* of the Code to furnish two test specimens for each 100 lineal ft of welded joint?

Reply: The Boiler Code Committee recommends that the provisions of Par. P-102*b* be considered as being complied with if two test specimens are furnished for each 100 lineal ft of welded joint.

CASE No. 755

Inquiry: Will it be permissible to connect an automatic water-feeding device to the $^1/_2$-in. water-glass connection of a low-pressure heating boiler, provided there is no external use therein of steam or water from the boiler?

Reply: Where a water-gage glass is connected directly to a steam boiler it is the opinion of the Committee that no other connection should be attached to the gage-glass outlets. If a water column or the equivalent is used on a boiler, or steam and water connections are available for one, attachments may be made to the connecting piping for appliances that are not intended to provide for a normal external use of steam or water from the boiler unit.

BOOK REVIEWS AND LIBRARY NOTES

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Trustees, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets, and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Plywood

Plywood: Its Production, Use, and Properties. By Alexander Mora. *Timber & Plywood*, London, 1932. Cloth, $5 \times 7^1/_4$ in., 420 pp., illus., 7s 6d.

Reviewed by Thomas D. Perry[1]

THIS book describes the various types of plywood made by various processes, both in the United Kingdom and the United States. The steps in the manufacturing process are logically outlined, with particular reference to production methods in the United Kingdom, but with comments indicating the variation of these processes as practiced in the United States and Continental Europe.

The book as a whole is aimed particularly at acquainting the purchaser, broker, and merchandiser of wood products with the character of plywood, its markets, and its types of products that are acceptable in the different markets.

The earlier part of the book treats of the technique of preparing veneer and lumber for plywood gluing operations; and of the gluing methods with wet glue and cold presses as well as with dry glue and hot presses. The proper sizes and kinds of plywood for the general market are also outlined. It is indicated that, in many parts of the world, plywood is especially made for industrial requirements rather than for warehousing in standard stock sizes. This is a tendency that is particularly prevalent in the United States.

Principles of Woodworking

Principles of Wood Working: A Survey of Present Knowledge on This Subject. Forest Products Research Laboratory, Princes Risborough, Bucks, England, 1931. Paper, $7^1/_4 \times 9^1/_2$ in., 35 pp., illus., 2s 6d.

Reviewed by Thomas D. Perry[1]

THIS pamplet proves to be by far the most constructive outline yet published of the fundamentals of how and why edged and toothed tools cut wood.

The preliminary outline of the theory of cutting wood with saws and knives, contained in "Reducing Waste in the Design of Woodworking Saws and Knives" by the Special Research Committee on Saws and Knives of The American Society of Mechanical Engineers in October, 1928, has been analyzed further and developed in a constructive manner by the United Kingdom's Forest Products Research Laboratory.

The fundamental principles of cutting with stationary and revolving edged tools of various kinds; with circular, continuous, and reciprocating saws with different types of teeth; and with revolving boring tools, have been carefully codified and developed into definite mathematical equations in the appendices of this bulletin.

Far-seeing woodworking engineers have for some time realized that such analytical codification was an essential step in making progress along the line of scientifically designed wood-cutting tools, both to serve the needs of the industry and to conserve the available, although diminishing, supply of growing and maturing timber.

A bibliography of the meager literature on the subject is included, in which special reference is made to the work of The American Society of Mechanical Engineers already mentioned.

Industrial Temperature and Humidity Measurement and Control

Handbook of Industrial Temperature and Humidity Measurement and Control. By M. F. Béhar. Instruments Publishing Company, Pittsburgh, Pa., 1932. $6 \times 9^1/_4$ in., 320 pp., 287 illus., \$4.

Reviewed by H. Diederichs[2]

THIS book comprises Parts II and III of the "Manual of Instrumentation," of which Part I, the Fundamentals of Instrumentation, appeared in the spring of 1932.[3]

Part II, on temperature measurement and control, consists of seven chapters: Temperature—General; Indicating Thermometers; Thermoelectric Pyrometers; Radiation and Optical Pyrometers, Pyrometric Cones, Etc.; Temperature Recorders; Automatic Temperature Control; and Temperature-Control Instruments and Accessories.

The first chapter deals with the definition of temperature, discusses the various scales, and ends with a classification of industrial temperature instruments. The next three chapters present a very complete discussion of the various industrial methods for measuring temperature, while the one on temperature recorders shows how the various primary temperature indicators may be used in order to furnish continuous records of temperature. In the nature of things these chapters are largely a compilation and a description of existing types of apparatus, but the text is up to date and very complete, and

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[2] Professor and Head of the Department of Experimental Engineering, Cornell University, Ithaca, N. Y. Mem. A.S.M.E.

[3] Reviewed in Mechanical Engineering, November, 1932, p. 806.

the author discusses the merits and demerits of the various instruments without fear or favor.

It is when he comes to discussing automatic temperature control and control instruments that the author is compelled to break new ground. He deals with the modes of control very fully and very graphically, and follows this with a discussion on the selection of the proper controller, location of the primary element, classes and types of elements, thermal systems, relays, and power devices. The last chapter in this section is devoted to temperature-control instruments and is of course largely descriptive.

Part III, on humidity measurement and control, consists of four chapters: Humidity—General; Humidity Measurement; Humidity and Aerological Measuring Instruments; and Automatic Control of Humidity. The first chapter is non-mathematical, the second deals in concise mathematical fashion with the principles of humidity measurement. The two combined make an excellent survey for those engineers who wish a quick and complete review of this topic. The third chapter presents a complete description of indicating and recording instruments used for humidity determinations. The last chapter deals with humidity control, and discusses in turn control principles, classes of application, relation of humidity control to air conditioning, classes of control instruments, and typical industrial humidity apparatus. To the reviewer's knowledge it offers for the first time a fairly complete survey of the important and growing field of humidity control.

There are ten appendixes, dealing with such topics as temperature conversion tables, thermometric lag, emergent stem corrections, psychometric table, etc.

It is evident that the author worked in close conjunction with the experts and scientists attached to the outstanding instrument companies of the country, an attitude that can only be commended. He has succeeded in presenting in compact form the most complete treatise on temperature and humidity measurement and control that has as yet come to the attention of the reviewer.

Engineering: A Career—A Culture

ENGINEERING: A CAREER—A CULTURE. By the Education Research Committee, the Engineering Foundation. The Engineering Foundation, New York, 1932. Paper, 6 × 9 in., 61 pp., illus., $0.15.

REVIEWED BY FRANKLIN J. KELLER[4]

THIS year marks the end of a quarter-century of conscious effort in the field of vocational guidance. Twenty-five years ago a group of interested persons gathered together and founded the Vocations Bureau in Boston, and since that time not only has the need been recognized, but numerous and varied efforts have been made to help young people and adults to adjust and readjust themselves to occupational life. Literally thousands of different pamphlets and books on vocational opportunities have been printed and distributed among teachers, counselors, and children. It might be supposed that standards of form and content had been agreed upon, but there is still much diversity of opinion as to what the character of a good job monograph ought to be.

On the one hand, accuracy of information has been set above all other qualities, while, on the other hand effective presentation has been the desideratum. Excess of accuracy leads to boredom, while emphasis upon style soon degenerates into sentimentalism. Most presentations of job information lean toward one or the other of these extremes.

[4] Director of the National Occupational Conference, New York, N. Y.

Writers of material of this kind usually fail to consider those elements which lead people to read what others write. They fail to determine what people are interested in jobs at all. In this connection I have two theories: One is that nine persons out of ten select jobs, even when they know all the facts in the case, because of the total compensation, monetary and environmental; and the second is that they continue to like a job because of the emotions aroused during the performance of it. It is comparatively easy to tell an inexperienced person what the financial rewards of a job are, but it is exceedingly difficult to convey to him a realization of the feelings he will experience when actually engaged in it. The perfect guidance pamphlet would present all the facts with absolute accuracy, and would at the same time arouse on the reader's part feelings akin to those he would experience in the occupation which was being described.

The present pamphlet is commendable in its attempt to present an accurate picture of the activities of engineering. The sterling integrity and the zeal and enthusiasm of the persons writing it bespeak the faith of the engineer in his profession. The defects of the presentation are the result of its virtues. The very subtitles: "A Career—A Culture; A Message to Young Men, to Parents and Teachers," constitute a credo which borders dangerously upon proselyting. The pamphlet assumes that the reader wants to be an engineer, and will only refrain from becoming one if he feels in all humility that he is not virtuous enough to engage in the calling. There appear to be no aspects of the profession which make for unhappiness, and it would seem that whatever blemishes may appear in the picture can be removed by the enthusiastic, intelligent, virtuous, and industrious young man.

Everything that is in the pamphlet should be said, but there are drawbacks to engineering which it does not mention. No profession can be as good as all that, not even the "most universal."

For instance, it would be most desirable to make a few comparisons, point for point, with other professions. It is only fair to give the young man a picture of the distribution of the occupations of men trained as engineers. How many are doing the work of the engineer, and how many are doing routine technical jobs, or are in organizations which do not utilize engineering training? How many men trained as engineers are failures? How many boys being graduated from engineering schools in 1932 are now employed? The chart showing the earnings of engineers ought to indicate the distribution of earnings rather than medians, even though the group is divided into three classes.

Much more attention should be paid to the rearrangement of the qualifications of individuals for successful careers in engineering. Some concrete instances illustrated by "psychological profiles" of both successful and unsuccessful engineers would be helpful. The boy ought to know something about the effects of technological changes upon the career of engineering. What is the skill of the engineer doing to the engineering profession itself? Is it working him out of a job?

The fact that the members of a profession attempt to analyze their own tasks and to present the result of their analyses to the young men of the land so that at the same time individuals will be helped and the dignity of the profession maintained, is a most hopeful sign. The Engineering Foundation is to be commended for the intelligence and enterprise which it has shown in producing this pamphlet. It is to be hoped that it will reissue the material from time to time, revising it in the light of the reactions of readers, and of teachers and counselors who use it as a medium of vocational guidance for their pupils.

Books Received in the Library

ALLOYS OF IRON AND MOLYBDENUM. (Alloys of Iron Monograph Series.) By J. L. Gregg. McGraw-Hill Book Co., New York and London, 1932. Cloth, 6 × 9 in., 507 pp., illus., diagrams, charts, maps, tables, $6. As the first of a proposed series of monographs upon ferrous alloys, the Engineering Foundation issues this summary of our knowledge of the molybdenum steels and irons. The book is based upon an exhaustive, critical review of the information scattered through volumes of periodicals and books in many languages, which is here woven into a connected account in usable form. Both practical men and research workers will find the volume indispensable. A valuable bibliography is included.

ANALYTICAL MECHANICS FOR ENGINEERS. By F. B. Seely and N. E. Ensign. John Wiley & Sons, New York, 1933. Cloth, 6 × 9 in., 414 pp., diagrams, tables, $3.75. Presents those principles of mechanics that are essential for engineers. The book aims to present them clearly, to develop them from common experience, to apply them to concrete practical problems, and to emphasize the physical interpretation of them. The new edition has been revised and reset.

APPLIED X-RAYS. By G. L. Clark. Second edition. McGraw-Hill Book Co., New York and London, 1932. Cloth, 6 × 9 in., 470 pp., illus., diagrams, charts, tables, $5. Professor Clark's book is intended for the industrial executive who wishes to know what X-rays are, how they may be used, and the ways in which they can be applied to practical industrial problems. The first section discusses the general physics and applications of x-radiation, the second the analysis of the ultimate structures of materials. The new edition is entirely rewritten.

ATM ARCHIV FÜR TECHNISCHES MESSEN. Nos. 15–18, September–December, 1932. R. Oldenbourg, Berlin and Munich. Paper, 8 × 12 in., illus., diagrams, charts, tables, 1.50 rm. each. The Archiv für Technisches Messen is an encyclopedia of technical measuring instruments and methods, which is being published serially in loose-leaf form. The articles are concise and well-illustrated practical descriptions, usually with bibliographies, and are signed. All classes of measurements are included. The numbers make much recent information available in convenient form for reference.

BERECHNUNG GEGLIEDERTER KNICKSTÄBE. By D. Rühl. V.D.I. Verlag, Berlin, 1932. Paper, 6 × 8 in., 89 pp., charts, tables, 5.50 rm. An exhaustive study of the calculation of the strength of lattice columns, in which the various methods of calculation in use are studied in comparison with each other and with test results. Many points of dispute are reconciled and simple conclusions for practical use are presented.

BIBLIOTHEKEN GESTERN UND HEUTE. (Deutsches Museum Abhandlungen und Berichte, Vol. 4, No. 5.) By H. Uhlendahl. V.D.I. Verlag, Berlin, 1932. Paper, 6 × 8 in., pp. 131–151, 0.90 rm. An address delivered at the dedication of the library of the Deutsches Museum by the Director of the Deutsche Bücherei. Sketches briefly the evolution of libraries from the earliest times to today.

CELLULOSE ACETATE, Its Manufacture and Applications. By A. G. Lipscomb. Ernest Benn, Ltd., London, 1933. Cloth, 6 × 9 in., 304 pp., illus., diagrams, charts, tables, 21s. A clear exposition of the manufacture of cellulose acetate and acetate rayon is given in this work, which brings together in an orderly way much scattered information. Both processes and plant equipment are described in detail. Laboratory control processes are discussed, and there are chapters on dyeing and printing, and on the use of cellulose acetate for other purposes. A very full list of British patents is included, and the book is well indexed.

CHEMISTRY AND TECHNOLOGY OF CRACKING. By A. N. Sachanen and M. D. Tilicheyev; translated by A. A. Boehtlingk, D. F. Brown, and K. T. Steik. Chemical Catalog Co., New York, 1932. Cloth, 6 × 9 in., 389 pp., diagrams, charts, tables, $8. The former Director and Chief Chemist of the Petroleum Research Institute of Grozneft present the results of four years of investigation upon the physical and chemical laws that govern the process of "cracking" petroleum. The fundamental features of cracking, the cracking of crude oil, the chemistry of the process and the chemical composition of the products, and cracked gasolines, kerosenes, and heavy distillates are discussed, the principal cracking systems are described, and hydrogenation is considered.

COMMITTEE ON WELDED RAIL JOINTS. FINAL REPORT. By American Bureau of Welding and American Electric Railway Engineering Association with the cooperation of the National Bureau of Standards. American Bureau of Welding, New York, 1932. Paper, 6 × 9 in., 358 pp., illus., diagrams, charts, tables, $1. During the past ten years this Committee, appointed by the American Bureau of Welding and the American Electric Railway Engineering Association, has been engaged, with the cooperation of the Bureau of Standards, upon a study of welded rail joints, looking toward their improvement. The results of this study, which have appeared from time to time in progress reports, are now presented in orderly arrangement in this volume.

DESIGN OF STEEL MILL BUILDINGS and the Calculation of Stresses in Framed Structures. By M. S. Ketchum. Fifth edition. McGraw-Hill Book Co., New York and London, 1932. Cloth, 6 × 9 in., 632 pp., diagrams, charts, tables, $6. This book is intended to occupy a position between elementary books on stresses and more elaborate treatises on bridge design. It provides a short course, much of which is applicable to all classes of steel-frame construction, although the book is chiefly concerned with mill buildings. In the present edition the specifications have been modernized, designs for a research building, a hangar and an air dock have been added, and a chapter included upon the calculation of stresses in stiff frames by moment distribution.

DEUTSCHE TECHNISCH-WISSENSCHAFTLICHE FORSCHUNGSSTÄTTEN. By Dipl.-Ing. Boeck. V.D.I. Verlag, Berlin, 1930–1931, Part 1, 135 pp.; Part 2, 445 pp. Pt. 1, 5 rm.; Pt. 2, 10 rm. This useful handbook gives essential information upon German and Austrian institutions for the advancement of science and technology. Part one gives the essential facts about 182 scientific and technical societies, with alphabetical, subject, and geographical indexes, and a list of the periodicals issued by them. Part two gives similar data for 850 research institutions.

ECONOMIC TENDENCIES IN THE UNITED STATES. By F. C. Mills. National Bureau of Economic Research, New York, 1932. Cloth, 6 × 9 in., 639 pp., diagrams, charts, tables, $5. This is primarily a survey of economic tendencies which developed and prevailed during the period 1922–1929, preceding the current depression. In order to bring out clearly the character of these tendencies, they are reviewed in comparison with those prevailing during the period preceding the World War. It continues the general price investigations of the National Bureau of Economic Research and extends work done in connection with the survey published by the Committee on Recent Economic Changes. The work presents an immense amount of information upon production, costs, prices, capital, income, etc., carefully analyzed and discussed.

FORSCHUNGSINSTITUT FÜR WASSERBAU UND WASSERKRAFT e. V., MÜNCHEN. MITTEILUNGEN. Heft 1, 1928. R. Oldenbourg, Münich and Berlin. Paper, 8 × 11 in., 39 pp., illus., diagrams, charts, tables, 4 rm. The investigations of discharge coefficients and pool formation were made upon models and upon the actual works themselves. Discharge coefficients obtained in the two cases agreed closely, but the conclusions concerning pool formation derived from the model varied greatly from actuality. The measurement of water by overflow weirs was also investigated and certain possible sources of error discovered.

DIE GRUNDGESETZE DER WÄRMEÜBERTRAGUNG. By H. Gröber and S. Erk. Second edition. Julius Springer, Berlin, 1933. Cloth, 6 × 9 in., 259 pp., illus., diagrams, charts, tables, 22.50 rm. The aim of this work is to present a systematic collective account of the whole field of heat conduction and heat transfer. In the first section the analytic theory of heat conduction is presented in convenient form for use in engineering. The second section discusses the movement of heat in liquids, and radiation is treated in the third. A collection of useful numerical tables is appended.

HANDBOOK OF BUTANE-PROPANE GASES. Edited by G. H. Finley. Calif., Western Gas, Los Angeles, Calif., 1932. Leather, 9 × 12 in., 279 pp., illus., diagrams, charts, tables, $5. This handbook, the joint work of several specialists, gives a comprehensive, practical survey of the liquefied-petroleum-gas industry. The manufacture and transportation of liquefied petroleum gases, and their distribution through central plants or in bottles for industrial and domestic fuel are described. The physical and chemical properties are considered, and attention is paid to appliances. A directory of central plants is included, and there is a useful bibliography.

HEAT TRANSMISSION. By W. H. McAdams. McGraw-Hill Book Co., New York and London, 1933. Cloth, 6 × 9 in., 383 pp., illus., diagrams, charts, tables, $5. An important, comprehensive treatise, prepared under the auspices of the Heat Transmission Committee of the National Research Council. The fundamental principles of heat transmission by conduction, radiation, and convection are presented. The literature and many unpublished data have been critically examined and correlated for the important cases of heat transfer, and the results

presented as formulas and graphs for use in engineering design. There is a bibliography of over four hundred items.

HIGH SPEED DIESEL ENGINES, with special reference to Automobile and Aircraft Types. By A. W. Judge. D. Van Nostrand Co., New York, 1933. Cloth, 6 × 9 in., 248 pp., illus., diagrams, charts, tables, $3.25. An elementary text for engineers and students, in which our knowledge of the theory of the high-speed compression-ignition engine is outlined and its practical aspects are discussed. The design and operation of many types of automobile and aircraft engines are described, with special attention to British practice.

HOUSING OBJECTIVES AND PROGRAMS. Edited by J. M. Gries and J. Ford. President's Conference on Home Building and Home Ownership, Washington, D. C., 1932. Cloth, 6 × 9 in., 345 pp., illus., $1.15. This final volume of the publications of this Conference contains the reports of the six correlating committees, appointed to review the conditions revealed by the fact-finding committees and to present conclusions. Reports are published upon Technological Developments in Housing, Legislation and Administration, Standards and Objectives, Education and Service, Organization Programs, and Research. Engineers will take special interest in the first of these reports, which calls attention to possible economies in building construction.

HYDRO- UND AERODYNAMIK, Rohre, Offene Gerinne, Zähigkeit. (Handbuch der Experimental Physik, Vol. 4.) By Dr. L. Schiller. Akademische Verlagsgesellschaft, Leipzig, 1932. 719 pp., illus., diagrams, charts, tables, 10 × 7 in., 67 rm. The results of modern research in the various branches of hydrodynamics and aerodynamics which are concerned with the flow of fluids in pipes and channels and with the study of viscosities are systematically reviewed by an authority upon each subject in the three articles that form this volume. An admirable view of research methods and results is given, of value to all those in search of basic principles.

INTERPRETATION OF THE ATOM. By F. Soddy. John Murray, London, 1932. Cloth, 6 × 9 in., 355 pp., illus., diagrams, charts, tables, 21s. Professor Soddy's work, "The Interpretation of Radium," was one of the best presentations of the subject available to the general reader in search of an account of our knowledge of the nature of matter. The present volume, written to take the place of the former one, has the same purpose. The first section gives a very full account of the discoveries in radioactivity from Becquerel's original discovery onward. Part two deals with the wider application of these discoveries and of the conceptions of quanta, relativity, and wave mechanics, to the chemistry of the atom. The author throughout avoids the use of mathematics.

INTRODUCTION TO INDUSTRIAL MANAGEMENT, Text, Cases, and Problems. By E. C. Robbins and F. E. Folts. McGraw-Hill Book Co., New York and London, 1933. Cloth, 6 × 9 in., 356 pp., illus., diagrams, tables, $3. A textbook for an introductory course, in which text, cases, and problems are blended in a treatment intended to develop ability to analyze practical problems.

JAHRBUCH 1932 DER DEUTSCHEN VERSUCHSANSTALT FÜR LUFTFAHRT, E. V., Berlin-Aldershof. Edited by W. Hoff. R. Oldenbourg, Munich and Berlin, 1932. Cloth, 8 × 12 in., 518 pp., illus., diagrams, charts, tables, 35 rm. The first section of the Yearbook describes the work of the German Experimental Institute for Aviation and gives brief abstracts of some two hundred papers, mostly unpublished as yet. The second section contains fifty-three papers of importance. Among these are reports upon flight tests for the measurement of polar curve and influence of slipstream; the German investigation of the Meopham accident; investigations of landing-wheel tires; aircraft engine construction; light alloys; blind landing; and lateral stability. The volume provides a great collection of experimental data upon all phases of aviation.

ÜBER KOMBINATION VON NITROZELLULOSE MIT OLEN. (Fachausschuss für Anstrichtechnik, No. 14.) By H. Wolff. V.D.I. Verlag, Berlin, 1933. Paper, 8 × 12 in., 18 pp., illus., diagrams, charts, tables, 3.70 rm. A systematic study of lacquers composed of oils and nitrocelluloses, in which the effects of changing the oils and nitrocelluloses used and of varying the proportions are investigated. The factors that affect the lacquer are discussed and correct lines of procedure indicated.

MACHINE TOOL WORK. Fundamental Principles. By W. P. Turner. McGraw-Hill Book Co., New York and London, 1932. Cloth, 6 × 9 in., 424 pp., illus., diagrams, charts, tables, $3. A systematic presentation of the subject, representing the course given at Purdue University. It covers the fundamental problems common to all kinds of machine-tool work, except the design and operation of complicated automatic or single-purpose machines.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN, GHH-KONZERN, Vol. 2, No. 3. V.D.I. Verlag, Berlin, October, 1932. Paper, 9 × 12 in., pp. 57–78, illus., diagrams, charts, tables, 2.50 rm. This number contains a further contribution by J. Geiger to the theory of speed meters; a study by J. Kusenberg of the relations between the length, span, and sag of ropes, in which approximate formulas are developed for determining the effect of temperature upon the deflection of suspension bridges; and an article by G. Heidhausen upon the use of spectrum analysis in the works laboratory for analyzing metals.

MODELMAKER for those interested in making working models. Edited by W. Edmunds Spon. Vol. 9. Spon & Chamberlain, New York; E. & F. N. Spon, Ltd., London, 1932. Cloth, 5 × 7 in., 432 pp., illus., diagrams, charts, $2.25. Modelmakers will find interesting information upon the construction of miniature locomotives, engines, motor boats and other machines in this volume, which contains twelve numbers of the magazine, substantially bound and indexed.

NEW INTERNATIONAL ASSOCIATION FOR THE TESTING OF MATERIALS. FIRST COMMUNICATIONS. 1930. 4 vols. Groups A-D. NIATM, Zurich, Switzerland, 1930. Cloth, 8 × 11 in., illus., diagrams, charts, tables, $10. These volumes, the first published by this organization, consist of brief reports upon selected subjects of importance in connection with the testing of materials, designed to exhibit the present state of knowledge. The reports are grouped in four volumes, dealing respectively with metals, inorganic non-metallic materials, organic materials, and questions of general importance. The reports, by various authorities, are printed in English, French, or German, with English summaries in all cases.

PRAKTISCHE GROSSZAHL-FORSCHUNG. By K. Deaves. V.D.I. Verlag, Berlin, 1933. Cloth, 6 × 8 in., 132 pp., diagrams, charts, tables, 7.20 rm. The use of statistical analysis for the control of quality and waste in manufacturing is systematically presented in this work, intended for manufacturers and engineers. Simple, practical methods are described for collecting and analyzing data and formulating rules for quality control. The methods are almost entirely graphical.

PROCÉDÉS MODERNES DE DÉCOUPAGE ET D'EMBOUTISSAGE. By E. Kaczmarek. Translated from German edition by A. Schubert. Dunod, Paris, 1933. Paper, 7 × 10 in., 253 pp., illus., diagrams, charts, tables, 67 fr. Modern press-working of metals is discussed in a practical manner in this work. Cutting and forming dies, presses, and other tools are described and their use illustrated by numerous examples. A chapter on costs is included.

REFRIGERATION, including Air Conditioning and Cooling and Household Automatic Refrigerating Machines. By J. A. Moyer and R. U. Fittz. Second edition. McGraw-Hill Book Co., New York and London, 1932. Cloth, 6 × 9 in., 538 pp., illus., diagrams, charts, tables, $5. Intended both as a textbook and reference work, this volume is a useful outline of current conditions and practice. The theory of refrigeration and the methods in use are described and explained. New features in this edition are descriptions of improved designs of household and small commercial refrigerators, silica-gel systems, revised data on refrigerants, production of dry ice, applications of quick freezing, and air conditioning.

SCHRAUBGETRIEBE, ihre mögliche und ihre zweckmässigste Ausbildung. By F. G. Altmann. V.D.I. Verlag, Berlin, 1932. Paper, 8 × 12 in., 30 pp., illus., diagrams, charts, tables, 5.30 rm. In view of the increasing use of worm gears for automobile drives, Dr. Altmann has studied the possible forms with a view to determining the most effective. Tooth forms, ease of cutting, lubricating characteristics, efficiency, and other points are discussed. Much of the information is new and potentially useful to manufacturers of gears and gear-cutting machinery.

SCIENCE MUSEUM, South Kensington. HANDBOOK of the Collections Illustrating PUMPING MACHINERY, Part 1, Historical Notes. By G. F. Westcott. H. M. Stationery Office, London, 1932. Paper, 6 × 10 in., 103 pp., illus., tables, 2s. 6d. An admirable brief review of the development of pumps from the earliest times to the present day.

THE STANDARDS YEARBOOK, 1933. The Standards Year Book for 1933, compiled by the Bureau of Standards, has recently been issued by the Superintendent of Documents. This is the seventh year in which this work has been published.

In it are outlined the activities and accomplishments of not only the bureaus and agencies of the Federal government, but also those of states and counties. It contains a résumé of the standardization work

of scientific and technical societies and trade associations. A brief account of international cooperation in standardization is followed by a summary of the activities of the national standards associations of the various countries.

It is a standardization reference book, summarizing current standardization activities and outstanding accomplishments during the year. It informs the manufacturer of the current standardization movements affecting his industry, the purchasing agents of new standard specifications, and the scientist engaged in research as to current research projects which may lead to standardization.

Specifications and Methods of Test for Refractory Materials and Manual for Interpretation of Refractory Test Data, prepared by Committee C-8 on Refractories. American Society for Testing Materials, Philadelphia, 1932. Paper, 6 × 9 in., 93 pp., diagrams, charts, tables, $0.50. The various publications of the society pertaining to the specification and testing of firebrick and other refractory materials are here brought together in a convenient form.

Steam Power Plant Engineering. By L. A. Harding. John Wiley & Sons, New York, 1932. Cloth, 7 × 9 in., 777 pp., illus., diagrams, charts, tables, $10. This book is intended to replace the "Power Plant and Refrigeration" volume of Harding and Willard's "Mechanical Equipment of Buildings." Its aim is to outline briefly, in an elementary manner, the major problems in the design of steam generators, engines, turbines, and accessories, to show their interrelations in power-plant engineering, and to discuss the economic factors involved in their selection. A large amount of practical data, not readily accessible elsewhere, is assembled in convenient form, making the work useful for reference, as well as for study.

Structural Mechanics. By H. W. Hayward, A. F. Holmes, and R. G. Adams. McGraw-Hill Book Co., New York and London, 1932. Cloth, 6 × 9 in., 182 pp., diagrams, charts, tables, $2.25. This textbook has been prepared for students in the Lowell Institute Free Evening School and is intended to enable them to follow succeeding courses in structural design and machine design, or as preparation for more advanced courses in structural mechanics. It is a complete revision of an earlier work by Professor Hayward. The book is intended for those familiar with the calculus, which is used freely.

Symposium on Steel Castings. American Society for Testing Materials, Philadelphia, and American Foundrymen's Association, Chicago, 1932. Paper, 6 × 9, 254 pp., figs., tables, $1. The symposium comprises the papers and discussions at a joint meeting, Atlantic City, N. J., June 21, 1932, of the American Foundrymen's Association and the American Society for Testing Materials. The symposium was planned and supervised by an able and representative committee under the chairmanship of W. C. Hamilton, research director, American Steel Foundries. The ten papers which are the basis of the symposium are introduced by a general survey of the steel castings industry written by the committee's chairman. This is followed by papers on the statistics of steel casting production in the United States, notes on the design of steel castings, purchase requirements for steel castings, physical and mechanical properties of some well-known cast steels, representative properties of cast medium pearlitic steels, corrosion-resistant steels, austenitic manganese steel castings, problems and practices in the heat treatment of steel castings, and fusion welding as related to steel castings. The oral and written discussion that the presentation of these papers provoked is included in the publication.

Copies of the symposium may be obtained by writing to either of the organizations mentioned or to the Secretary, The American Society of Mechanical Engineers.

Tables Annuelles de Constantes et Données Numériques de Chimie, de Physique, de Biologie et de Technologie, Vol. 8, 1927–1928, Part 2. Gauthier-Villars et Cie, Paris. McGraw-Hill Book Co., New York, 1932. Cloth, 9 × 11 in., 2706 pp., diagrams, charts, tables. The new volume of this invaluable reference book fills the gap in the series, which now is complete through 1929. An immense quantity of physical, chemical, engineering, and metallurgical numerical data is made available, and the necessity for searching through periodicals is obviated. The text throughout is in English as well as French. References to the sources of the data are included.

Textile Analysis. By S. R. Trotman and E. R. Trotman. J. B. Lippincott Co., Philadelphia, 1932. Leather, 6 × 9 in., 301 pp., illus., diagrams, charts, tables, $6.50. This treatise contains a comprehensive collection of carefully selected methods for the determinations required of analytical laboratories in textile plants. Methods are given for identifying and determining textile fibers, for the usual physical tests, and for analyzing fibers, oils, dyestuffs, starches, glues, bleaching agents, metallic salts, etc. The work covers most of the subjects with which textile chemists have to deal.

Textile Research, a Survey of Progress, compiled by the United States Institute for Textile Research, Inc. Technology Press, Massachusetts Institute of Technology, Cambridge, 1932. Cloth, 6 × 10 in., 264 pp., illus., diagrams, tables, $2.50. This volume contains twenty-two reviews, by recognized authorities, of the progress made during the last decade in research in the textile industry. Improvements in physical and chemical testing; the results of research upon cotton, wool, silk, rayon, asbestos, and bast fibers; the present technology of cotton, woolen, silk, and rayon manufacture; the dry-cleaning and laundry industries; finishing and economic research are reviewed.

Theory of Functions. By E. C. Titchmarsh. Clarendon Press, Oxford; Oxford University Press, New York, 1932. Cloth, 6 × 9 in., 454 pp., $7.50. This book, an introduction to various branches of the theory of functions, both real and complex, is intended to bridge the gap between the elementary textbooks and the systematic treatises. Among the topics discussed are analytic continuation, power series, integral functions, Dirichlet series, Lebesgue integration, and Fourier series.

Thermodynamics. By J. E. Emswiler. McGraw-Hill Book Co., New York & London, 1932. Cloth, 6 × 9 in., 347 pp., diagrams, charts, tables, $3. The special feature of this textbook is the order of presentation of the subject, this being a progression from the topics most familiar to the student to those with which he is inexperienced. Study of the steam engine comes first, followed by vapor refrigeration, permanent-gas mixtures, and air heat engines. Finally the laws of thermodynamics and the kinetic theory of heat are discussed. This edition has been partly rewritten and new matter added.

Die Thermodynamische Berechnung der Dampfturbinen. By G. Forner. Julius Springer, Berlin, 1931. Cloth, 6 × 10 in., 126 pp., illus., diagrams, charts, tables, 8.50 rm. This book is intended for engineers familiar with the theory of the steam turbine who are faced with the problem of designing one. In a fully worked numerical example, the author shows, step by step, how the thermodynamic calculations are made.

Untersuchungen an Fahrbaren Förderbändern für den Baubetrieb. (Mitteilungen des Forschungsinstituts für Maschinenwesen beim Baubetrieb, Heft 4.) By M. R. Ehrt. V.D.I. Verlag, Berlin, 1932. Paper, 8 × 12 in., 18 pp., illus., charts, tables, 4.50 rm. A report of an investigation of the capacity, power consumption, efficiency, etc., of belt conveyors for handling sand, gravel, and concrete in building construction. Ten different conveyors were tested and compared with hand methods of handling.

Verfrachtung und Frachtkostenberechnung im Technischen Überseehandel. By K. B. Osburg. V.D.I. Verlag, Berlin, 1932. Cloth, 6 × 8 in., 102 pp., illus., diagrams, charts, tables, 6.90 rm. A practical handbook for exporters which presents practical methods for determining freight charges and best methods of packing and shipping machinery.

Versuchsfeld für Maschinenelemente der Technischen Hochschule zu Berlin. No. 9. Untersuchungen an Zylinder- und Globoid-Schneckentrieben, by G. Maschmeier. R. Oldenbourg, Münich and Berlin, 1930. Paper, 8 × 11 in., 47 pp., illus., diagrams, charts, tables, 4 rm. In the first part of this study the behavior of worm gears is investigated theoretically and a method devised for determining the flank velocity and its distribution over the tooth surface from the path of contact, by means of which the behavior of various worm gears can be predicted. In the second part the method is applied to two worm gears, one cylindrical, the other of the hourglass (Hindley) type. The experimental results agreed with the theoretical ones.

Versuchsfeld für Maschinenelemente der Technischen Hochschule zu Berlin. No. 10. (1) Ermittlung der Berührungsverhältnisse von Globoidschneckentrieben, by W. Duhnsen. (2) Ölmengenmessungen an Ringschmierlagern, by K. Müller. R. Oldenbourg, Münich and Berlin, 1931. Paper, 9 × 12 in., 42 pp., diagrams, charts, tables, 5 rm. In the first of these reports, the behavior of the contact surfaces of hourglass (Hindley) worm gears is investigated and a purely geometrical method for determining the path of contact given, by means of which conclusions can be derived concerning the behavior of a given gear. Recommendations for cutting and use are given. The second paper describes measurements undertaken to determine the behavior and efficiency of ring oilers, especially upon heavily loaded bearings.

VIBRATION PREVENTION IN ENGINEERING. By A. L. Kimball. John Wiley & Sons, New York, 1932. Cloth, 6 × 9 in., 145 pp., illus., diagrams, charts, tables, $2.50. The theory of vibration and its application to the prevention of vibration in engineering structures is presented concisely, yet with sufficient comprehensiveness, according to the author, to handle effectively any of the problems that usually arise. The book is based upon the direct experience of the author in the engineering work of the General Electric Company and represents a series of lectures that were recently delivered at the Harvard Engineering School.

WAVE MECHANICS, Elementary Theory. By J. Frenkel. Clarendon Press, Oxford, England (gift of Oxford University Press, N. Y.), 1932. Cloth, 7 × 10 in., 278 pp., diagrams, 20s. This is the first volume of a treatise in three volumes, each complete in itself, which is intended to replace the author's "Einfuehrung in die Wellenmechanik;" it is, however, practically a new work. The present volume gives a general survey of the whole subject of wave mechanics and of the new quantum statistics connected with it and also discusses the application of the quantum statistics to the electron theory of metals.

WINDKRAFTWERKE. By H. Honnef. F. Vieweg & Son, Braunschweig, 1932. Paper, 6 × 10 in., 111 pp., illus., diagrams, charts, tables, 4.80 rm. Presents a plan for utilizing wind power for the large-scale production of electricity. The scheme contemplates the erection of towers, 600 feet or more high, carrying groups of air turbines. The book describes the calculation and design of the power plant, discusses costs, etc.

WHAT'S GOING ON

The Century of Progress Exposition

THE American Society of Mechanical Engineers, with other societies, assisted in the early plans of the Century of Progress Exposition, having suggested advisers to make it one of outstanding engineering and scientific interest. Engineering Week and Engineers' Day at the Exposition will focus public attention upon engineering developments. A gathering in Chicago of more than a dozen engineering and technical societies gives the profession an unusual opportunity to demonstrate the importance of its activities upon the progress of the world.

The Exposition will be composed of buildings of general and unusual interest. Features that will be of special interest to engineers are the Hall of Science, the buildings of the electrical group, the Travel and Transport Building, the Agricultural Building, the Social Science Building, and the General Exhibits Building.

The Hall of Science is the nucleus of the Exposition. It stands in a prominent position, its 176-ft tower brilliantly illuminated in the evening. Its exhibits will portray the story of the epochal discoveries of science which have helped to make our world what it is.

Another building of almost equal interest is the Travel and Transport Building. The dome of this unique structure is suspended by cables attached to twelve steel towers arranged in a circle. The interior, with a clear diameter of 206 ft and approximating the height of a twelve-story building, provides a large, unobstructed arena which is ideal for exhibits of unusual size, such as locomotives. The main building is 1000 ft long and two stories in height. In both the domed part and the hall there will be exhibits showing man's progress in transportation throughout the ages.

On Northerly Island will be located the Communications Building and the Electrical Building, the first being square in shape, and the latter a three-quarter circular building surrounding a court and rising from a series of terraces. This building will portray electrical developments, many of the latest being adequately exhibited for the first time.

The immense Agricultural Building will house exhibits showing the origin and evolution of crops and explaining the food value of products of the soil. The development of farm marketing and improvements in farm equipment will be set forth. The live-stock and meat industry and the dairying industry will be adequately represented. Five pavilions will house the general-exhibits group.

Other major units are the Hall of Horticulture and the Hall of Social Science, devoted to anthropology, psychology, sociology, economics, and political science, as well as demonstrating practical uplift work. The home and industrial arts will contain fine examples of modern housing, home conveniences, and labor-saving devices.

Plans for Engineering Week, June 25 to 30

ANNOUNCEMENT has previously been made in these columns of Engineering Week to be held during the Century of Progress Exposition in Chicago, Ill., June 25 to 30, of Engineers' Day at the Exposition (Wednesday, June 28), and of the Chicago Power Show, to take place at the Coliseum during Engineering Week.

Plans for Engineering Week are rapidly taking form. Among the features of the week will be the joint session of all engineering societies under the auspices of Section M of the American Association for the Advancement of Science, at which an address will be given by Dr. A. P. M. Fleming, of Manchester, England, who will discuss "Progress in Science in the Past Century." There will be a joint dinner at the Hotel Stevens on Wednesday evening, June 28, at which the Guggenheim Medal, an award of The American Society of Mechanical Engineers and the Society of Automotive Engineers, will be presented to Juan de la Cierva, the inventor of the autogiro. The Marburg Lecture, by Dr. Herbert J. Gough, of Teddington, England, will be delivered on Tuesday afternoon, June 27. A meeting under the auspices of the Econometric Society, The American Society of Mechanical Engineers, and the American Society for Testing Materials, at which the joint interests of scientific economists and engineers will be discussed, will be held on Friday, June 30. During the week, the Society for the Promotion of Engineering Education will celebrate its fortieth birthday, it having come into being as a result of an educational conference held in Chicago at the time of the World's Columbian Exposition, in 1893.

The complete program of the activities of The American Society of Mechanical Engineers during Engineering Week will be a feature of the June issue of MECHANICAL ENGINEERING. An extensive program of technical papers is being put into shape.

Second National Lubrication Engineering Meeting

THE Second National Lubrication Engineering Meeting will be held at Pennsylvania State College, State College, Pa., May 25 and 26, under the auspices of the College and the Lubrication Engineering Committee of the A.S.M.E. Petroleum Division.

On the first day of the meeting the following papers will be presented: "Practical Interpretation of Lubricant Specifications," by J. G. O'Neill, U. S. Engineering Experiment Station, Annapolis, Md.; "Machine Design for Lubrication," by E. M. Barber and C. C. Davenport, Pennsylvania State College; "Roll-Neck Lubrication," by W. D. Hodson, Hodson Corp., Chicago, Ill.; and "Lubricant Viscosity Standardization for Industrial Equipment," by Dr. A. E. Becker, Standard Oil Development Co., New York, N. Y.

On Friday the papers will be: "Applications of Extreme-Pressure Lubricants to the Lubrication of Industrial Machinery," by Dr. O. C. Bridgeman, Bureau of Standards, Washington, D. C.; "Problems of Lubricating Heavy-Duty Gears," by Austin Kuhns, Farrell-Birmingham Co., Buffalo, N. Y.; "Wire-Rope Lubrication: (*a*) Hemp Core, (*b*) Wire Strands, (*c*) Relubricating in the Field," by A. J. Morgan, John A. Roebling's Sons Co., Trenton, N. J.; to be followed by a discussion of "Friction of Wire Ropes in Sheaves," by L. M. Tichvinsky, Westinghouse

Elec. & Mfg. Co., East Pittsburgh, Pa.; and "Some Practical Factors Affecting Design and Operation of Bearings for Large Rotating Apparatus," by T. W. Gordon, A.-C. Engineering Dept., General Electric Co., Schenectady, N. Y.

The headquarters of the meeting will be at the Nittany Lion Inn, State College. Further details of the program may be secured from Prof. F. G. Hechler, Pennsylvania State College, State College, Pa.

World Power Conference Sectional Meeting, 1933

THE World Power Conference Sectional Meeting, 1933, begins at Copenhagen, Denmark, at 1 p.m., Monday, June 26. On the night of June 27 members of the conference will proceed to Stockholm, where the official inauguration will take place at 2 p.m., June 28, with an address by H.R.H. Gustaf Adolf, the Crown Prince of Sweden. Technical sessions will commence on Thursday, June 29, and continue through July 4. July 5 and 6 will be devoted to comprehensive tours in Sweden, which will be continued in Norway on July 7 and 8, the final session of the conference taking place in Oslo on July 8.

In connection with the Sectional meeting, the First International Conference on Large Dams will be held in Stockholm, June 28 to July 1. Immediately before the meeting the Seventh International Conference on Large High-Tension Systems will be held in Paris.

The headquarters of the American Committee, World Power Conference, is Rooms 1419–1421, Chrysler Building, 405 Lexington Ave., New York, N. Y.

1933 Economic Conference for Engineers

FOR two seasons, 1931 and 1932, an Economic Conference for Engineers has been held at the engineering camp, Johnsonburg, N. J., of Stevens Institute of Technology. A third conference will be held August 12 to 20, 1933, with a special week-end program on August 18, 19, and 20. While no subject for the 1933 Conference has been definitely decided on, a suggestion under consideration is "New Developments in Banking and Currency."

Lamme Medal Awarded to Edward Weston

THE 1932 Lamme Medal of the American Institute of Electrical Engineers has been awarded to Dr. Edward Weston, Montclair, N. J., Mem. A.S.M.E., "for his achievements in the development of electrical apparatus, especially in connection with precision measuring instruments," and will be presented at the Summer Convention of the Institute which is to be held in Chicago, Ill., June 26–30, 1933.

The Lamme Medal was founded as a result of a bequest of the late Benjamin G. Lamme, chief engineer of the Westinghouse Electric & Manufacturing Company, who died on July 8, 1924. It provided for the award by the Institute of a gold medal for "meritorious achievement in the development of electrical apparatus or machinery."

Research Aid Fund

THE National Research Council has been given the administration of a limited fund from which grants can be made during the year 1933 toward the support of the research work of individual investigators in the fields of the natural sciences. This fund is in charge of a special committee of the Research Council, known as the Committee on Grants-in-Aid, composed of the chairman and the treasurer of the Council, together with the chairmen of the Council's seven divisions of science and technology.

Correspondence in regard to applications for grants should be addressed to the Secretary, Committee on Grants-in-Aid, National Research Council, 2101 Constitution Ave., Washington, D. C.

Members of the A.S.M.E. interested in applying for grants are also urged to communicate with the Society's main Research Committee, which is in a position to obtain support for such requests through the Society's representatives on the Division of Engineering and Industrial Research of the Council.

Conference on Re-Engineering for Economical Manufacture

ON May 10 to 12, at Cleveland, Ohio, the Case School of Applied Science is to hold a conference on Re-Engineering for Economical Manufacture. The program begins on Wednesday evening, May 10, with a joint meeting with the Cleveland Section of the A.S.M.E. and the Cleveland Engineering Society at 8 p.m., at the Hotel Statler, at which John Carmody, management consultant, of New York, N. Y., will speak on "Planning for Profits." The sessions on Thursday and Friday mornings and afternoons will be held in the Physics Building of the Case School of Applied Science.

A registration fee of $2 will be charged for attendance at all sessions or a fee of 75 cents for attendance at a single session. Further information may be obtained from Prof. E. S. Ault, Case School of Applied Science, Cleveland, Ohio.

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after May 25, 1933, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member having comments or objections should write to the Secretary of the A.S.M.E. at once.

In addition to the names given are a group of approximately 980 transfers from Student to Junior membership, whose names will appear on the ballot for May 20.

New Applications

Aboozbeer, Azeez E., Boston, Mass.
Anderson, Eliot, Warwick, N. Y.
Ballenger, Robert O., Wilmington, Del.
Barnes, Malcolm Harold, McComb, Miss.
Berg, Charles C., Wilmington, Del.
Charignon, M. J., Fargo, N. D.
Dalway, Benjamin C., New York, N. Y.
Dell, Ernest R., Philadelphia, Pa.
Doering, Walter C., St. Louis, Mo.
Dutton, David, Burlingame, Kans.
Ellwood, George E., Rio de Janeiro, Brazil
Embree, Harold A., Grant, Iowa
Endlein, Carl, Brooklyn, N. Y.
Fast, Frank, Brooklyn, N. Y.
Finch, Carl V., Berkeley, Calif.
Galata, Richard L., Brooklyn, N. Y.
Gorney, Henry Stanley, Wilmington, Del.
Hill, George M., Riverside, Calif.
Jacobson, John S., Wilmington, Del.
Johnson, Miles H., San Francisco, Calif.
Lee, Chun C., Canton, China (Rt. & T.)
Lyles, Leonard C., Chicago, Ill.
McDonough, W. J., Toronto, Ontario, Canada
McGrath, Joseph F., Yonkers, N. Y.
Mehta, T. C., Narainganj, Bengal, India
Neu, H. J. E., Lille (Nord), France
Newell, Francis M., Wilmington, Del.
Schmarje, Clarence F., Iowa City, Iowa.
Schuckhart, Josiah B., San Francisco, Calif.
Zimmerlund, Leonard E., Newburgh, N. Y.

Change of Grading

Transfer from Associate-Member
Dunnell, William W., Jr., Boston, Mass.
Transfers from Junior
ap Rhys Pryce, M. A., Port au Prince, Trinidad
Bieser, Carl W., Cincinnati, Ohio
Davidson, H. O., Meadville, Pa.
Elsas, Norman E., Atlanta, Ga.
Fitzpatrick, William H., Beechhurst, N. Y.
Krieg, Edwin H., Newark, N. J.
Peragallo, Joseph, Rochester, N. Y.
Ritchie, Paul, Millville, N. J.
Robertson, J. M., Houston, Tex.
Sizer, William D., Harrison, N. J.
Stewart, Harvard Paul, Berkeley, Calif.
Stone, Daniel C., Germantown, Phila., Pa.
Swab, Edwin M., Barberton, Ohio
Thomas, R. W., Detroit, Mich.
Tod, James R., New York, N. Y.
Torres, Angel, Santurce, Porto Rico

Coming Meetings of A.S.M.E. Local Sections

Bridgeport: May Meeting. Subject of meeting is to deal with recent developments in submarine navigation etc., with reference to Wilkins' trip to the North Pole, as well as the newest craft invented by Simon Lake for underwater salvage work.

Kansas City: May 23. Ambassador Hotel at 8 p.m. Annual dinner and election of officers for 1933–1934.

New Haven: May 17. Meeting of the Connecticut Sections of the A.S.M.E. to discuss a State Engineering Council. L. W. Wallace will speak in the evening. Dinner at New Haven Country Club.

Oregon: May 26. Portland Hotel at 7:30 p.m. Prize papers will be submitted by members of Student Branches.

William Cawthorne Unwin, 1838-1933

(*Continued from page 305*)

many engineers and financiers were engaged in the historic events of those days, Professor Unwin played an important part that was in keeping with his character, training, and methods of work. For Professor Unwin was primarily a teacher and an investigator who analyzed and rationalized engineering science and practice and put the results of his studies and experiences in such a form as to make them available for all men, in all lands, and for all time.

William Cawthorne Unwin was born on December 12, 1838, at Coggeshall, Essex, the son of Dr. W. J. Unwin, principal of Homerton College. Following his education at the City of London School, he was, by good fortune, associated in Manchester with Sir William Fairbairn, whose contributions to engineering literature and research have kept his memory alive. Fairbairn found in the young Unwin a man of similar aptitude and zeal for research and rational statement of empirical practices. Together they conducted a series of tests on the properties of steam, the strength of plate girders, and the collapse of tubes. By 1861 Unwin was manager of an engineering works manufacturing the vortex hydraulic turbine, where he acquired that personal contact with men and engineering practice without which the research worker and scholar are likely to remain impractical theorists.

Professor Unwin's career as a teacher began in 1868 with an appointment as professor at the Royal School of Naval Architecture and Marine Engineering in South Kensington. Four years later he was made professor of hydraulic engineering at the Royal Indian Engineering College, Coopers Hill, and in 1884 became the first professor of engineering at the Central Technical College of the City and Guilds of London. In the fulfilment of this office he rendered notable services to the school and to engineering education, and continued with his researches on the steam engine and the mechanics of materials.

No student of engineering can have escaped the influence of Professor Unwin's work. If his most notable textbooks, "The Elements of Machine Design," "Wrought Iron Bridges and Roofs," and "Testing Materials of Construction," are today not actually studied, for indeed they have been replaced by more modern texts, no later books on any of these subjects, or upon hydraulics, can be found without reference to his work, or without a formula bearing his name. For it was his especial ability to study the underlying theory, the practice, and the experimental researches in connection with these subjects and to evolve fundamental formulas upon which engineers and designers could place reliance. While no great engineering structure stands today called by his name because his genius brought it into being as concrete evidence of a man's ability to perform spectacular engineering feats, it would not be an exaggeration to say that his work influenced those who have erected such monuments and provided at least some of the tools wherewith the designer worked.

One other factor of Professor Unwin's interests deserves comment in this brief review because of the importance that engineers in this country are today attaching to it. This is his work for the advancement of the professional status of the engineer and the esteem in which the profession is held. He was president, in 1911, of the Institution of Civil Engineers, and, in 1915, of the Institution of Mechanical Engineers. To both of these institutions he devoted much time and labor in the development of examinations for membership. His addresses before these institutions will repay careful reading, particularly those parts that refer to engineering education, research, the induction of young engineers into the profession, and the value of engineering societies to their members. On this final topic a paragraph from his 1915 address is worthy of quotation. He said: "The Institution as a corporate body of men of similar avocations is a source of strength to all its members. It gives publicity to the work of engineers, which is essential in creating the estimation in which they are held by people outside the profession. It is able to secure facilities and gifts, and it elicits and records information of great value which would otherwise remain private property. One has heard of persons who think that because they cannot attend the meetings in London, and have no time to study the Proceedings, they can get no benefit from the Institution. The case is rather an extreme one. Bacon said that every man is a debtor to his profession, and it follows that he has a duty to support whatever benefits it. Most of us subscribe to objects from which we expect no direct recompense, and few engineers could say that they receive no indirect benefit from the work done here. Knowledge diffuses itself in various channels, and improvements in industrial methods bring advantage to many who do not know where they originate."

Professor Unwin died on March 17, 1933. In an appreciative obituary in *Engineering* it is said: "In him has passed away a great teacher, a sound engineer, and a fine character."

Magnetism and the Structure of Metals

(*Continued from page 289*)

By superposing two deposits in which the magnetization is first in one direction and then in a normal direction, it is possible to get more complete deposits.

And finally we come to the most interesting results of the investigation.[3] Deposits obtained on large crystals of iron, nickel, and cobalt showed a new and unexpected structure. These structures are to be seen only on the surfaces of undistorted crystals, as, for instance, on the surface of an ingot. No patterns have been found on ground or polished samples unless annealed.

In Fig. 6 the deposit found on a nickel crystal is shown. The direction of magnetization is more or less at right angles to the direction of the lines in the deposit. Such line patterns are to be found on both iron and nickel crystals, though the split lines shown in Fig. 6 are characteristic of nickel. Although on occasion the deposits resemble slip lines, they could not be structural features of this kind, as they are not fixed in the material. It is possible to get the same deposit over and over as long as the magnetization of a sample is not changed. After demagnetization a new set of lines is formed looking very much like the old set, but some or all of the lines will be found shifted to a new position. In Fig. 7 is shown the deposit found on an unmagnetized cobalt crystal. This pattern changes considerably with magnetization, as is shown in Fig. 8. Various peculiarities of the phenomenon have been observed, but will not be further discussed here. The reader is referred to the original paper for further information.[3]

There is much work to be done in clearing up the origin of these patterns. So far nothing is known of the effect of temperature, and almost nothing of the effect of strains. Further investigations on crystals of alloyed materials should also be instructive. The technique required is so simple, and the results to be expected so striking, that we may hope to have at least the experimental data necessary to an understanding of the observed effects available before long.

[3] *Physical Review*, vol. 41 (1932), p. 507.